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Criteria for Developing Pollution Abatement Programs for Inactive and Abandoned Mine Sites

Skelly and Loy, Harrisburg, Pa

Prepared for

Environmental Protection Agency, Washington, D C Office of Water Planning and Standards

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CRITERIA FOR DEVELOPING POLLUTION ABATEMENT PROGRAMS FOR INACTIVE AND ABANDONED MINE SITES

U.S. ENVIRONMENTAL PROTECTION AGENCY
Washington, D.C. 20460

REPRODUCED BY
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This report is issued under Section 304(e)(2)(B) of Public Law 92-500. This Section provides:

> "The Administrator, after consultation with appropriate Federal and State agencies and other interested persons, shall issue to appropriate Federal agencies, the States, water pollution control agencies, and agencies designated under Section 208 of this Act, within one year after the effective date of this subsection (and from time to time thereafter) information including...(2) processes, procedures, and methods to control pollution resulting from -
>
> (B) mining activities, including runoff and siltation from new, currently operating, and abandoned surface and underground mines...."

This publication is the third in a series issued under Section 304(e)(2)(B) of Public Law 92-500 concerning the control of water pollution from mining activities. The initial report, "Processes, Procedures and Methods to Control Pollution from Mining Activities", was issued in October 1973 (Publication No. EPA-430/9-73-011).

This report provides information for developing alternative pollution abatement programs for inactive and abandoned mine sites. Sufficient descriptive information is provided to guide the reader in the tentative selection of alternative measures to be applied in specific cases. The details of application and methods of construction of each measure must be ascertained on a case-by-case basis by qualified professionals in the mining and water pollution control fields.

Mark A. Pisano, Director
Water Planning Division

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This report is prepared in response to the requirements of P.L. 92-500, Section 304(e)(2)(B). The study involves the development of abatement criteria for all mined mineral commodities except oil and gas production, well sites and off-shore mining. All abandoned or inactive surface underground mines, attendant waste piles, road storage areas and other related facilities are included in the report.

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* * *

Prepared for
Office of Water and Hazardous Materials
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Washington, D.C. 20460

* * *

AUGUST, 1975

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EXECUTIVE SUMMARY

INTRODUCTION

The specific objective of this report is to present criteria for statewide pollution abatement programs for inactive and abandoned (orphan) mine sites. This information is intended to be used by the United States Environmental Protection Agency as a basis for providing programmatic guidance to states conducting or anticipating establishing an abandoned mined land pollution abatement and reclamation program.

Nationwide in scope, the study involved development of abatement criteria for all mined mineral commodities except gas and oil production, well sites and offshore mining. All abandoned or inactive surface and underground mines, attendant waste piles, roads, storage areas and related facilities are included.

In developing criteria and determining alternative mechanisms for a statewide pollution abatement program, the study was divided into three major parts:

1. Background information concerning mineral commodity extraction and pollution problems

2. Organizational, financial and legal considerations in implementing a program

3. Technical approach to establishing a mined lands pollution inventory and site reclamation program

Development of a comprehensive program requires knowledge and understanding of these interrelated aspects.

MINERAL COMMODITY EXTRACTION

In order to establish a government agency to administer an abatement program, it is important that creators (of an agency) are knowledgeable as to the nature, extent and significance of the problem within their state. It is toward that end this report includes basic, but generalized information on mining, environmental impact and reclamation potential.

Two primary mining methods - surface and underground - are employed in mineral extraction. Basic factors involved in determining types of mining method utilized for a particular mineral deposit are grade of ore, physical character of ore deposit and associated ratio of overburden thickness to mineral thickness. Surface mining is preferred, where possible, over underground methods because of its higher mineral recovery, much greater production per man-day, more economical operation in terms of capital costs and cost per unit, better health and safety conditions and more flexibility of operation.

The mineral industry in the United States annually produces some 80 mineral resources to help fulfill the needs of our industrialized society. In 1972, the value of domestic production of primary minerals and mineral fuels was valued at $32.2 billion. Furthermore, value of mineral production is expected to grow at an annual rate of 1.8% with a concomitant quantitative increase of 4% to the year 2000.

By 1971, a total of 1.5 million hectares (3.65 million acres) were disturbed by the mining industry. This represents 0.16% of total land resources; however, 60% remains unreclaimed. Of this unreclaimed land 80% is associated with surface mining, 8% with underground mining, and 12% with mining waste area. In addition to land affects, surface mining by 1965 adversely affected approximately 21,000 kilometers (13,000 miles) of stream, 40,000 surface hectares (100,000 surface acres) of natural lakes and 17,000 surface hectares (42,000 surface acres) of reservoirs and impoundments.

ENVIRONMENTAL IMPACT

Mining activities, from exploration through and including processing, obviously can disturb the environment. Current legislative controls and guidelines (in most states) help minimize operational and post-operational effects from mining; however, this has not always been the case. The results from past mistakes or lack of control are abandoned mined sites. Environmental impacts from these abandoned or inactive mine sites generally fall into one or more of the following categories:

1. Water quality degradation
2. Altered landscapes
3. Air pollution

The degree of impact is dependent on the mining methods utilized, physical and chemical characteristics of the mineral commodity and overburden, along with general hydrology and climatology conditions of the area.

RECLAMATION - ENVIRONMENTAL POTENTIAL

Once initial land disturbance occurs, natural factors influence future land and water utility. Method of mineral extraction and subsequent abandonment sets an initial determining factor in any reclamation plan. Socio-economic considerations determine funding and the desired end result of reclamation.

Justification for reclamation expenditures is usually judged by cost-effectiveness and benefits achieved. Projects low in cost but effecting removal of large amounts of pollutants, and gaining multiple land and water uses receive high priority. Restoration of abandoned mined lands and surface waters can be achieved for one of the following categories; its associated costs will depend on initial suitability of the disturbed area.

1. Agricultural
2. Pasture
3. Timber and pulp
4. Rangeland or forest
5. Wildlife habitat
6. Water related recreation
7. Reservoir
8. Home development
9. Industrial park
10. Commercial building site
11. Sanitary landfill

Increases in land values after reclamation are primarily dependent on land use category and proximity to urban areas.

ACTIVE MINE CLOSURE

The final operation of any mining activity is mine closure, which requires careful consideration in order to minimize subsequent water pollution, establish aesthetic scenery, eliminate potentially hazardous conditions, and facilitate future land utilization. Planning for mine abandonment should begin as an integral part of initial mine design and be implemented in conjunction with final reclamation procedures.

By employing preplanned mine closure many post-mining problems can be eliminated. For example, design of underground mines for down-dip development can facilitate inundation and sealing by lessening the potential hydrostatic head pressure against seal installation. Surface mining operations can also accrue benefits such as preventing a deficit of spoil for final backfilling through proper planning and management of spoil placement and/or transport during overburden excavation.

There are certain mine closure procedures that apply to all types of mines. Listed below are general measures that pertain to general site rehabilitation rather than the specific area directly affected by excavation and mineral extraction.

1. Remove all mineral stockpiles
2. Dispose or revegetate waste stockpiles
3. Remove all trash, equipment, buildings and structures
4. Backfill all surface depressions
5. Dewater tailings ponds and backfill
6. Revegetate all affected land including haulroads and preparation facilities
7. Construct safety barriers such as fences and impassable flora hedges around hazardous areas
8. Provide water infiltration control measures
9. Provide erosion control measures

The evaluation and recommendations pertaining to closure and abandonment of mines on cessation of mining is extremely important, because active mines today will become pollution sources tomorrow if they are improperly closed or abandoned.

DEVELOPMENT OF STATEWIDE PROGRAMS

As increased funds become available for abatement and reclamation purposes, many states are expected to develop statewide programs. For many states, this will represent a first-time effort and it will be necessary to work through intricate details of organization, administration, management and finance. The forehand knowledge of the key elements essential for a successful program, obstacles and opportunities within existing state programs which would lend insight into structuring a new program include:

1. Program coordination, integration and communication
2. Fiscal resources to carry-out program goals
3. Establishment of clear-cut lines of authority
4. Effective program planning and management
5. Well trained and experienced leadership

The establishment of an administrative authority to handle a statewide pollution abatement program may be accomplished a number of different ways. The most commonly used methods are the following:

1. Redefining powers and duties of an existing government agency
2. Reorganization of an agency, thus creating a new agency
3. Establishing an interagency coordinating council
4. Creating a special board or commission

Two of the most important aspects of a program's structure are development of goals and objectives, and implementation strategies. Basic criteria which should be considered in developing goals and objectives include:

1. Relevancy to existing state environmental, economic, social and political conditions

2. Technical, economic, legal and political feasibility

3. Congruity with other federal and state environmental programs, funding requirements and legal mechanisms

LEGAL PROBLEMS AND AVENUES OF SOLUTION

Initially a state must define its legal status and mechanisms available to handle a complex abatement and reclamation program. This can be accomplished using a team of attorneys (either in-house or a consulting law firm) to research and digest current federal, state and local laws. This analysis should identify many of the legal problems most likely to occur during implementation of the program.

Final output from this initial legal investigation should be a report with sufficient detailed recommendations for action that would enable a bill to be introduced into state legislature which would provide legal authority to carry out the pollution abatement and reclamation program.

Substantial legal problems arise in determining which of three parties is to bear the cost burden of abatement - private landowner, current generation of miners, or the state. A program can begin with the easiest projects first - abandoned land which is publicly owned -- then work up to the more complex problems. Other means would create incentive programs for reaffecting previously mined lands either by landowners or mining companies. Utilization of nuisance laws, health codes, environmental codes, and water quality laws; all must play an active role if significant progress is going to be made in the forseeable future.

PROGRAM FUNDING AND ASSISTANCE POSSIBILITIES

Financial and technical assistance is available from federal, state, local and private sources to carry-out the task of reclaiming abandoned mined land. These sources of federal help can be divided into two major sectors:

1. Agencies that can supply financial, management, planning and technical help.

2. Agencies that supply only technical assistance which may be in the form of information, equipment or manpower.

Some sources of federal financial assistance available to states and most local government agencies are listed on the following page.

1. Department of Interior
    - Bureau of Outdoor Recreation
    - Bureau of Mines
    - Bureau of Land Management
    - Geological Survey
    - Bureau of Sport Fisheries and Wildlife
2. Energy Research and Development Administration
3. Department of Agriculture
    - Farmers Home Administration
    - Forest Service
    - Agriculture Stabilization and Conservation Service
    - Soil Conservation Service
4. Environmental Protection Agency
    - Office of Water and Hazardous Materials
    - Office of Research and Development
5. Department of Defense
    - Army Corps of Engineers
6. Department of Commerce
    - Economic Development Administration
7. Department of Housing and Urban Development
8. Department of Labor
9. Department of Health, Education and Welfare
10. National Aeronautics and Space Administration
11. Federal Energy Administration
12. Water Resources Council
13. Tennessee Valley Authority
14. Appalachian Regional Commission

TECHNICAL APPROACH TO ESTABLISHING THE MINED LANDS, POLLUTION INVENTORY AND SITE RECLAMATION PROGRAM

The objective of the administering state agency in an abandoned mined lands program is management of the state's total resources, which involves abatement of water pollution and restoration of the land. In order to successfully complete such a comprehensive program, a systematic and logical approach must be utilized. The exact method a state employs will depend on variables such as: financial resources; magnitude and diversity of the state's problem; staff size of the administering agency; and socio-economic needs of the state's residents. Since this document is designed as a general guide for many users, each step in the mined land inventory, data evaluation, and abatement and reclamation implementation process is presented with alternative methods or options which relate to the specific requirements and subsequent level of effort assigned to the project. Thus, regardless of the variables, one of the alternative or optional methods in each procedural step can supply some degree of information. For maximum efficiency, it is essential to define as many variables as possible at the start of the program and to determine the degree of detail necessary to accomplish program objectives. This will increase the usefulness of data and accuracy of evaluation, while reducing financial and manpower waste associated with collection of interesting but unusable information.

An areawide mined lands inventory will assess and document past pollution abatement and restoration efforts, and provide a sound basis from which to establish future program planning and priorities. In addition to summarizing and updating state mining information, it also places the state in an advantageous position to apply for and receive financial and technical assistance from federal sources.

A successful mine drainage abatement and mined land reclamation program should be comprised of the following inter-related steps:

1. Development of base mapping
2. Watershed definition
3. Water quality survey
4. Socio-economic survey
5. Mined lands survey
6. Reclamation and abatement cost development
7. Priority establishment
8. Final map development

A number of optional approaches are presented with each aspect, along with approximate costs where applicable.

Development of Base Mapping

Identification of the states' major problem areas must be completed before detailed aerial mapping is started. This reduces aerial photography cost by concentrating low level photos on areas affected by mining. The development of working base maps such as a U.S.G.S. topographic map is extremely important in planning and evaluation of the program surveys.

For final presentation of study data, it may be desirable to develop a composite of three overlays - culture, streams, and topography. The final map scale will depend primarily on size of the study area and volume and detail of data to be presented.

Watershed Definition

Verification and supplementation of historical records and aerial surveillance with ground surveillance should be undertaken on a watershed basis. The watershed sampling survey's objective is to supply additional data to the administering agency to establish accurate land inventory records needed to develop abatement and reclamation plans.

In order to develop comprehensive plans, detailed information is needed on water quality, aquatic ecology, terrestrial impact, reclamation potential, land use potential and socio-economic area needs. These factors are interrelated and jointly affect a geographic area, usually in the form of topographically defined watersheds rather than politically defined areas (towns, cities, townships or counties). This is true because mining and resultant pollution follow topographic, not political boundaries. It is therefore reasonable to develop surveys and evaluate their data by watersheds.

The size determination of the watershed depends on the complexity of the individual state abandoned mined land problems. Experience has shown a watershed of 130 to 260 square kilometers is often an ideal size for routine ground surveillance.

Water Quality Survey

Water quality evaluations in a statewide abatement assessment should consist of two distinct phases:

1. Collection, mapping and analysis of existing water quality and stream flow data
2. Establishment of new or repeat sample collection and flow measurement stations with subsequent sampling and data evaluation.

Survey parameters assessed, sampling frequency, techniques, and location, will depend upon the requirements of each individual study. In addition, funding availability, study area size, time constraints and nature of contaminants or pollutants attributed to the specific mining industry will play an important role in selecting biological, chemical and physical analysis parameters.

Socio-Economic Survey

A statewide pollution abatement and mine restoration program must encompass an assessment of an area's economic needs and developmental demands in establishing watershed ranking and reclamation priorities. Restoration programs may not be undertaken strictly for aesthetic environmental improvements, but can also attempt to improve utilization of local or regional water and land resources for the general public. Subsequent stimulation of an area's economy and other beneficial effects of such programs thus enhance general well-being of the citizenry.

Collection and analyses of socio-economic information may be accomplished utilizing any of a number of options, depending primarily on availability of state human resource data, economic needs, development demands and aesthetic interest of the citizenry. In areas where planning organizations are well developed at local levels, socio-economic information will be adequately documented and easy to assemble. However, not all states or areas will be lucky enough to be in this situation, and alternative mechanisms must also be considered. To accomplish the objectives of a statewide abandoned mined lands program, the following socio-economic components must be considered:

1. Human resources
2. Economic needs
3. Development demands
4. Aesthetics

The level and intensity of investigation can vary with the individual state program objectives and priorities.

Mined Lands Inventory

The primary objective of the mined lands inventory is the systematic and logical acquisition of information for characterization, ranking and establishment of statewide long range plans for restoration of abandoned mined land. The inventory process can consist of the following major components:

1. Aerial photography
2. Photography interpretation
3. Terrestrial survey - ground surveillance
4. Determination of land ownership

Each task further defines and evaluates the condition of the abandoned mined lands by some predetermined classification system. A typical mine classification system might involve five categories of mined land:

1. active surface mines;
2. mines that are generally completely reclaimed, requiring only local spot reclamation work;
3. mines in which only a minimal reclamation effort is required;
4. mined land requiring a moderate reclamation effort; and
5. mined land requiring extensive reclamation work.

This classification would then be refined by field effects using such parameters as degree of regrading, revegetation and spoil slope. These two classification systems could then be combined to form a matrix cross index classification.

The terrestrial survey is generally performed for the following reasons:

1. Establishing ground truth for photo-interpretation
2. Verification of existing historical data
3. Supplementing existing information through collection and analysis of field samples
4. Increasing the investigator's familiarity with overall field conditions

Reclamation potential of an abandoned mine site is directly related to the extent of environmental impact caused by extraction methods utilized during the mining cycle. Evaluation of watershed and mined land reclamation potentials should include data concerning the following:

1. Mining methods
2. Mineral commodity extracted
3. Age of disturbance
4. Acreage of mined site
5. Site conditions
6. Major environmental areas
    - Erosion and Sedimentation
    - Refuse or waste materials
    - Water
    - Toxic materials
7. Adjacent land uses

A major problem in abandoned mined land reclamation affecting priority establishment is the land ownership question. Public ownership of unreclaimed mined lands simplifies reclamation work in several ways. Access costs and problems are eliminated, and the question of benefiting private landowners with public funds does not arise. Land use and recreation benefits are generally higher for reclamation on public land versus private land. Reclamation results in upgrading of present public holding, but reclamation on private lands also benefits nearby public holding by upgrading area aesthetics and enhancing wildlife populations.

Reclamation Cost Development

The principal environmental damages resulting from mining of any mineral are disruption of the land surface and/or production of mine drainage pollutants which subsequently degrade surface and ground water. Statewide abatement planning studies should, therefore include mine drainage abatement as an integral part of the comprehensive long range mine reclamation program that is developed. Although many studies will be aimed at improvement of unreclaimed strip mined land in general, past experience in several states has shown that reclamation of these abandoned mines can, in many cases, only be justified by water quality improvement benefits.

Surface Mine Costs

Computation of surface mine reclamation costs for each of the study area watersheds should begin as the surface mine classification and signature work is completed. This phase of the study can proceed in several steps, including development of average reclamation costs, computation of areas, and calculation of costs.

Development of reclamation costs can best be accomplished utilizing mined land categories developed earlier in the study and applying unit costs to these classifications. This permits the total surface mine reclamation cost to be calculated for each watershed.

Underground Mine Costs

The task of establishing deep mine contributed acid loads and computing abatement costs can be extremely difficult, particularly where the study area is large or where study time and available information is limited. These problems do not affect the surface mine cost computations since those are based on accurate areas computed for each category of surface mined land, and on fairly straightforward cost per unit area figures. Underground mine pollution load estimates and abatement costs must be developed in an entirely different manner, and may represent one of the most complicated and difficult challenges of an entire statewide abatement program. The methods with which underground mine abatement costs can be estimated are highly variable, depending almost exclusively upon the amounts of deep mining and mineral geology information available. This, in turn, is at least partially related to the size of the study area and time allotted for the study. It may not be possible to compile extremely detailed information for a massive study area. The manner by which underground mine pollution abatement costs are estimated will, therefore, vary radically in different situations, and the final methodology for estimation will have to be established by project personnel in each individual study after assessment of available data.

Regardless of the option selected or devised for determination of deep mine pollution abatement costs, a system must still be devised to estimate the portion of each module or watershed's pollution load that emanates from underground mines. In nearly all situations, at least a portion of the abatement costs will have to be based upon the amount of underground mine pollution to be abated. The derivation of underground mine pollution abatement costs could proceed in a series of steps similar to those discussed below, according to the volume and detail of available background data. It must be pointed out that the methods discussed may vary with specific minerals, mining techniques, and available time.

Cost Effectiveness

The cost effectiveness of a mine reclamation and mine drainage abatement project is the cost in dollars of eliminating each unit weight of pollutant emanating from the subject site. These values provide an excellent means by which the relative effectiveness of various reclamation or abatement expenditures can be assessed and compared. Cost effectiveness values are generally obtained by dividing the reclamation or abatement cost by the pollution load attributed to that point source. In certain instances where land improvement rather than mine drainage abatement is the primary goal, cost effectiveness may be improved by dividing the total cost by the predicted land value increase. These values are computed individually for the surface mine reclamation work, the underground mine pollution abatement work, and the overall reclamation and abatement work in each of the study area's pollution producing watersheds.

Reclamation Priorities

Priority establishment in a statewide abatement planning program is one of the last phases of work, and is dependent upon successful acquisition and use of all available data. This phase is best accomplished by establishing a numerical system for computation of relative priority scores. Previous studies of similar nature have clearly shown that the prejudices of personnel establishing priorities are quite frequently reflected in the final outcome of the work, despite all efforts to eliminate bias. Establishment of a numerical system in which each distinct aspect of the data is assigned a weighted constant or rank according to its relative importance eliminates the possibility of biased rankings. Such a system can be established at any level of detail, thus the precision of the data acquired in the study need not be ruined by grouping it in some general, broad category.

A typical example of such a ranking system is presented below. For the purpose of discussion, we will assume that the principal parameters being considered are:

1. Mine drainage pollution
2. Development demand
3. Density of unreclaimed surface mines
4. Economic need
5. Public visibility
6. Visual quality
7. Public land ownership

Watersheds are grossly ranked individually in each of these categories as high, medium, low, and none, each level receiving a point assignment 3, 2, 1, 0 respectively.

The watershed characteristics are then assigned coefficients to adjust the relative importance of each characteristic in the final priority determination. This can usually be accomplished by a simple vote among the personnel of various professional disciplines who are involved in the project - having each memeber rate each of the characteristics in order or on a ten-point scale. In the example cited here, the following coefficients have been used:

Data Characteristic	Coefficient
Mine Drainage Pollution	9
Development Demand	9
Density of Unreclaimed Strip Mines	7
Economic Need	6

Public Visibility	4
Visual Quality	3
Public Land Ownership	1

The watershed priority value for each data characteristic is then determined by multiplying the data characteristic coefficient by the data characteristic rating. Watershed scores are then totaled, compared and divided into groups to establish overall priority ranking.

Final Mapping

Upon completion of data analysis and formulation of conclusions, development of mapping for general presentation of findings and conclusions can be finalized. Much of the information shown on these maps will have been plotted on at least a preliminary basis during the course of the study, either on the photomaps, topographic quadrangle maps, or other working preliminary base maps. Scales of the final mapping should be similar to the working base maps discussed in Base Map Development, and will include the photomaps delineating and classifying mined lands.

IMPLEMENTATION

Successful completion of a statewide mined lands inventory is a prerequisite to proper planning and performance of watershed feasibility studies and subsequent abatement or reclamation programs. From this initial statewide inventory program, priorities are established for future feasibility studies. A wealth of information assembled in the inventory is also available and relevant to the goals of the feasibility study. Therefore, the statewide inventory and subsequent watershed feasibility studies should be viewed as complementary and interdependent, although they are separate operations.

The specific objective of the watershed feasibility study is to obtain information necessary to implement a successful mine reclamation and mine drainage abatement program in the watershed.

Such a watershed feasibility study will:

1. Determine the extent and severity of mine drainage in the watershed's main stream and tributaries;
2. Evaluate aquatic and terrestrial ecosystems and the impacts of water quality upon them;
3. Assess baseline and socio-economic conditions and variations throughout the study area;
4. Conduct a pollution source inventory to locate and measure specific discharges associated with past and present mining;
5. Determine the impact of mine drainage on the primary receiving stream;
6. Recommend remedial measures for each significant source of pollution which can be reduced or eliminated by current technology;
7. Attempt to distinguish between the pollution loading contributions of active and inactive mines and between surface and underground mines;
8. Assess future mining potential within the study area;
9. Establish cost and cost effectiveness of these remedial measures, including a ranking of the measures according to recommended priority; and
10. Develop and recommend an "abatement plan" for the watershed.

Necessary to the implementation of a successful abatement program is careful, thorough analysis of the various available reclamation and abatement alternatives. The planning procedure and its execution must insure that the abatement and reclamation process yields the highest possible benefit for every dollar expended. Use of a specific, effective series of planning phases allow isolation of logically related, interdependent actions, and simultaneously provides a means of gauging overall progress.

The primary difference between tasks in the implementation phase and the statewide inventory phase is the degree of detail.

SECONDARY USES OF INVENTORY DATA

Inherent to the planning and evaluation of a statewide abatement and reclamation program is collection of tremendous amounts of qualitative and quantitative data. Depending upon the format and techniques utilized in data collection, much of this information can be used by other state, federal, and county government and non-government groups and individuals.

CONTENTS

Page

CONCLUSIONS 1
RECOMMENDATIONS 3
INTRODUCTION 5
    PURPOSE. 7
    SCOPE 7
    STUDY DEVELOPMENT 8
        Technical Aspects of Mineral Commodity Extraction 9
        Legal and Organizational Aspects of Implementing a Program 9
        Technical Approach to the Mined Lands and Pollution Inventory and Site Reclamation . . . 10

SECTION I - BACKGROUND INFORMATION

CHAPTER 1 - MINING 1-1
CHAPTER 2 - ENVIRONMENTAL IMPACTS OF MINING. . . 2-1
CHAPTER 3 - RECLAMATION-ENVIRONMENTAL POTENTIAL 3-1
CHAPTER 4 - ACTIVE MINE CLOSURE PROCEDURES . . . 4-1

SECTION II - THE MANUAL

CHAPTER 1 - DEVELOPMENT OF STATEWIDE PROGRAMS 1-1
CHAPTER 2 - LEGAL PROBLEMS AND AVENUES OF DEVELOPMENT 2-1
CHAPTER 3 - PROGRAM FUNDING POSSIBILITIES. 3-1
CHAPTER 4 - TECHNICAL APPROACH 4-1
CHAPTER 5 - IMPLEMENTATION 5-1
CHAPTER 6 - SECONDARY USE OF LAND INVENTORY DATA. 6-1

APPENDICES

APPENDIX A - MINING SUPPORT INFORMATION A-3
APPENDIX B - SYNOPSIS OF SELECTED STATE ABANDONED MINED LANDS PROGRAMS . . . A-51

Page

ILLINOIS ABANDONED MINE LAND RECLAMATION PROGRAM. A-52
MARYLAND ABANDONED MINE DRAINAGE CONTROL PROGRAM A-53
PENNSYLVANIA OPERATION SCARLIFT A-54
VIRGINIA ORPHANED LAND RECLAMATION PROGRAM A-55
KENTUCKY ORPHAN LAND RECLAMATION PROGRAM A-55
OHIO LAND REBORN A-56

APPENDIX C - GLOSSARY A-59
APPENDIX D - REFERENCES A-69
APPENDIX E - ACKNOWLEDGEMENTS A-79

LIST OF TABLES
APPENDICES

Table		Page
A-1	Mining Method, By Mineral	A-4
A-2	Mineral Values, By State	A-8
A-3	Mineral Production, By State	A-10
A-4	Mineral Production and Producing States, By Commodity	A-26
A-5	Number of Mines in 1972 By Commodity and Magnitude of Crude Ore Production	A-29

LIST OF FIGURES
APPENDICES

Figure		Page
A-1	Bauxite and Other Sources of Aluminum Reserves	A-30
A-2	Sources of Bituminous and Sub-bituminous Coal Reserves	A-31
A-3	Sources of Anthracite and Lignite Coal Reserves	A-32
A-4	Sources of Copper Reserves	A-33
A-5	Sources of Gold Reserves	A-34
A-6	Sources of Iron Ore Reserves	A-35
A-7	Sources of Lead Reserves	A-36
A-8	Sources of Manganese Reserves	A-37
A-9	Sources of Mercury Reserves	A-38
A-10	Sources of Mica Reserves	A-39
A-11	Sources of Molybdenum Reserves	A-40
A-12	Sources of Oil Shale Reserves	A-41
A-13	Sources of Phosphate Rock Reserves	A-42
A-14	Sources of Potash Reserves	A-43
A-15	Sources of Salt Reserves	A-44
A-16	Sources of Silver Reserves	A-45
A-17	Sources of Sulfur and Pyrite Reserves	A-46
A-18	Sources of Titanium Reserves	A-47
A-19	Sources of Tungston Reserves	A-48
A-20	Sources of Uranium Reserves	A-49
A-21	Sources of Zinc Reserves	A-50

CONCLUSIONS

- Utilization of 1.5 million hectares (3.7 million acres) of land by the mining industry has resulted in abandonment of 60% of this land. The adverse environmental impacts of these lands justifies expenditure of public funds for pollution abatement and reclamation programs.

- Development and execution of a successful statewide abatement and reclamation program should encompass:

  1. program organization and administrative structure
  2. legal mechanisms and constraints
  3. potential funding sources
  4. water quality and land inventory status
  5. technical aspects of mineral extraction
  6. abatement and reclamation program implementation including feasibility, design, construction, and post-construction monitoring and evaluation studies.

- Program effectiveness can largely be determined by the quality of decision-making and magnitude of political and legal mechanisms available to convert administrative decisions into actions.

- Maximum benefits may be derived from the program, if the total watershed picture is understood and considered before establishment of final priorities, which is based upon:

  1. natural resources
  2. socio-economics
  3. future mining trends
  4. cost effectiveness at primary and secondary benefit level

- Financial and technical assistance is available from many federal, state, industrial and private sources.

- Lead time for many program tasks such as funding, watershed feasibility studies and site feasibility and design is extremely long and must be defined well in advance of execution deadlines.

- Technical survey methodology of an abandoned or inactive mine site abatement and reclamation program will vary depending on the:

    1. long term goals
    2. short range objectives
    3. abandoned mined land status
    4. manpower and financial constraints

- Effective mine closure procedures of presently active mines can prevent the future degradation of our water and land resources.

RECOMMENDATIONS

- Projected increases in almost all aspects of mineral production and anticipated accelerated costs associated with abatement and reclamation programs. make it imperative that the federal government and individual states proceed immediately to correct the abuses of the past by:

  1. enacting stringent but technologically achievable and environmentally sound mining and reclamation laws, and funding to support said laws and programs;
  2. individual states enacting a comprehensive but equitable mining and reclamation program which

     - regulates present and future mining and reclamation practices, and

     - eliminates the adverse effects of inactive mined lands and associated areas.

- Update and revise existing state mineral reserve data and maps in order to identify those previously mined (unreclaimed) areas which could be reaffected by mining industry under today's more strict mining and reclamation laws.

- Develop incentive mechanisms to encourage the remining of those unreclaimed areas with remaining reserves. Potential mechanisms that should be investigated include:

  1. bounty (reward) per acre reclaimed;
  2. reduced tax assessment;
  3. reduced/prorated license fees;
  4. reduced interest on loans for reclamation projects; and
  5. expanded and better funded research and demonstration of mining and reclamation methods on previously mined areas.

- Statewide abatement efforts should proceed in an orderly and logical fashion:

  1. complete a statewide land and water quality inventory and selection of priority watersheds;

2. study analyses of priority watersheds and establish priority areas for feasibility studies;
3. engineering design study and development of specifications and documents;
4. construction and work phase; and
5. monitoring and evaluation of results.

- State abatement and reclamation programs should involve and define the respective roles of:

  1. federal and state agencies;
  2. regional and county governmental units;
  3. today's generation of miners; and
  4. private landowners.

- Program administration and implementation should be within a single agency.

- Individual states should establish specific rotary funds designated for mine abatement and reclamation work.

- Data gathered throughout the program should be made more readily available to the public and private sectors as well as other government programs.

- Legal and fiscal problems should be defined and resolved before initiating the feasibility and construction design phases.

- Inventory studies should yield (formulate) data base upon which subsequent studies can refine and expand. The inventory study phase should avoid collection of data which becomes antiquated quickly - within 2-4 year period.

- Once watershed priorities have been established, feasibility studies on high priority watersheds should be undertaken in a systematic manner.

INTRODUCTION

PURPOSE

Extraction of minerals from the earth's crust occurs in all fifty states, utilizing a variety of surface and underground mining techniques. By 1971, a total of 1.5 million hectares (3,650,000 acres) were disturbed by the mining industry. This represents 0.16% of total land resources. However, 60%, or approximately 0.9 million hectares (2,190,000 acres), remains unreclaimed.

Socio-economic stability and development of an area depends on wise use of all resources. These abandoned lands are a large, unusable natural resource which can be rehabilitated, restored or reclaimed to some useful purpose. The abandoned lands are frequently the source of water pollution caused by water contacting soluble materials such as pyrites, salts, metallic compounds, chlorides, phosphates and radioactive waste. The extent and chemical composition of the polluted waters depends upon mineral commodity mined, mining method utilized, extent of regrading and revegetation, and the area's climatology. Abatement of water pollution and reclamation of these abandoned mined lands can provide significant economic growth stimulus.

The specific objective of this project was to develop criteria for large area pollution abatement programs for inactive and abandoned mine sites. This information is intended to be used by the United States Environmental Protection Agency as a basis for providing programmatic guidance to states conducting abandoned mined land pollution abatement and reclamation programs. In addition, this document will supply a unified approach and guidance to local, interstate and other agencies involved in or proposing this type of program.

SCOPE

Nationwide in scope, the study involved development of abatement criteria for all mined mineral commodities except oil and gas

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production, well sites and offshore mining. All abandoned or inactive surface and underground mines, attendant waste piles, roads, storage areas and other related facilities are included in the study.

Objectives included developing parameters and guidelines for basic data collection (physical, chemical and biological, land use, and socio-economic characteristics); determination of potential land uses; estimation of land values; development of reclamation and pollution abatement costs; definition of legal tools available for reclaiming land; alternate solutions to legal problems; development of financing opportunities; recommendation of an optimum state organizational structure; develop procedural steps for mined land inventory, watershed ranking, reclamation priorities, implementation plans, monitoring and assessing reclamation results.

Although criteria development involved only inactive or abandoned mined lands abatement programs, evaluation and recommendations pertaining to closure and abandonment of mines on cessation of mining is relevant to the project, because active mines today will become pollution sources tomorrow if they are improperly closed.

STUDY DEVELOPMENT

In developing criteria and determining alternative mechanisms for a statewide pollution abatement program three major aspects must be considered:

1) technical aspects of mineral commodity extraction
2) legal and organizational aspects of implementing a program
3) technical approach to mined lands and pollution inventory and site reclamation

Each of these aspects are interrelated, and knowledge of this relationship is necessary for development of a comprehensive abatement program.

Technical Aspects of Mineral Commodity Extraction

In order to establish a state agency to administer an abatement program, it is imperative that the creators (of this agency) are knowledgeable as to the nature, extent and significance of the problem within their state. It is toward that end this report includes basic, but generalized information on mining, environmental impact and reclamation.

Determination of the extent of abandoned mined lands in general terms can be accomplished using mineral production, area affected, and reclamation figures. Mineral commodity mined and method of extraction are important because of their relationship with environmental impact (water quality degradation and land use disturbance) and reclamation potentials (land use, land values and reclamation costs). These interrelationships offer advantages in assessing general conditions. For example, if mining methods and/or mineral commodity mined are known, direct inferences can be made as to environmental condition of the land or water and potential uses.

In addition to a state's present condition, an understanding of the mineral commodity's reserves and mining trends offers an excellent opportunity to develop management plans for the future use of its total resources.

Legal and Organizational Aspects of Implementing a Program

At this point an organizational structure can be formulated to deal with a state's specific abandoned mined lands problems. The new organization's first task is to describe its long range and short term goals and objectives. Legal and constitutional questions and mechanisms have to be resolved prior to initiating any site reclamation. As the legal problems are being resolved the state can research potential funding sources. This research should include categorization of these sources as to availability for specific types of reclamation projects, including those which can assist in financing planning and land inventory phases.

Technical Approach to Mined Lands and Pollution Inventory and Site Reclamation

The primary objective of the mined land and pollution inventory survey is to systematically and logically obtain information for management of a program. The method utilized by any state agency will depend on: financial resources, magnitude and diversity of abandoned mined land and pollution problems, administering agency's staff size, and socio-economic needs of the state's residents.

This identification by means of literature review, aerial mapping, and field data collection should include relevant information on natural systems, water quality, terrestrial impact, land use, mining, reclamation potential, pollution abatement or control techniques, socio-economic condition and needs of the local residents. The interrelation of these factors within a geographic area in the form of a topographic watershed rather than a political division (town or county) suggests the use of watershed modules (or subbasins) as a working base unit for all data collection and evaluation. A watershed study design can be formulated around four distinct surveys: (1) water quality; (2) terrestrial impact; (3) reclamation potentials; and (4) socio-economics. Each survey, when independently evaluated and ranked, offers flexibility necessary to establish statewide abatement and reclamation priorities. This is particularly necessary in states encompassing large geographic areas, diverse mineral commodities and/or mining techniques.

Once watershed reclamation priorities have been established, detailed abatement and reclamation feasibility studies on high priority watersheds should be undertaken. A feasibility study involves conducting a detailed land and water inventory survey within that priority watershed to specifically identify and further define the general information obtained in the state inventory. This will supply data needed for engineering design and actual abatement and reclamation construction. The last step in the project is to monitor results of construction, which will supply feed-back necessary to improve effectiveness of the next watershed reclamation project.

SECTION I

BACKGROUND INFORMATION

A 11

CONTENTS
SECTION I

Page

CHAPTER 1 - MINING 1- 1

MINING METHODS 1- 3
  Surface 1- 3
    Open Pit. 1- 3
    Area Strip 1- 4
    Contour Strip 1- 5
    Auger 1- 5
    Dredge 1- 6
    Hydraulic 1- 6
    In Situ. 1- 6
  Underground 1- 7
    Stoping Methods 1- 7
      Supported Stopes - Natural. 1- 8
      Supported Stopes - Artificial. 1- 8
      Caved Stopes 1- 9
    Conventional 1-10
    Continuous 1-10
    Longwall - Shortwall 1-10
    Entryways. 1-11
MINERAL COMMODITIES IN THE UNITED STATES. . . 1-12
AREAS UTILIZED AND RECLAMATION BY THE MINERAL INDUSTRY 1-12
WATERWAYS AFFECTED BY THE MINERAL INDUSTRY 1-18
FORECAST OF FUTURE MINING TRENDS 1-34
  Forecast for Surface Vs. Underground Mining . . 1-46
FORECAST OF MINERAL COMMODITIES 1-50
  Metals 1-50
    Iron 1-50
    Aluminum 1-51
    Copper 1-51
    Lead 1-51
    Zinc 1-51
    Uranium. 1-52
  Nonmetallic Minerals. 1-52
    Stone 1-52
    Sand and Gravel 1-52
    Clay 1-53
    Salt 1-53
    Phosphate Rock 1-53
    Sulfur 1-53

A12

Energy 1-54
  Coal 1-54
  Oil Shale 1-55

CHAPTER 2 - ENVIRONMENTAL IMPACTS OF MINING 2- 1

IMPACTS OF SPECIFIC MINERAL INDUSTRIES 2- 3
IMPACTS OF SPECIFIC MINING TECHNIQUES 2- 5
  Open Pit 2- 5
  Area Surface. 2- 6
  Contour Surface 2- 7
  Auger. 2- 7
  Dredge and Hydraulic 2- 8
  Deep Well Extraction 2- 8
  Underground Mining 2- 8
IMPACTS OF ALL MINING TECHNIQUES 2- 9

CHAPTER 3 - RECLAMATION - ENVIRONMENTAL POTENTIAL 3- 1

NATURAL CHARACTERISTICS AFFECTING LAND UTILITY. . . . 3- 6
  Soil 3- 6
  Geology and Mineralogy 3- 7
  Hydrology and Water Quality 3- 7
  Topography. 3- 7
  Climate 3- 8
MINING DISTURBANCES AND RECLAMATION POTENTIAL 3- 8
  Open Pit 3- 8
  Area Mining 3-10
  Contour Mining. 3-11
  Mountain-Top Removal 3-11
  Auger 3-11
  Dredging 3-11
  Underground 3-12
LAND VALUES AND TAXES 3-12
BENEFITS DERIVED FROM LAND AND STREAM RECLAMATION 3-16
  Fishing and Hunting Benefits 3-19
  Recreation and Aesthetics 3-19
  Stream Non-Fishing 3-21
  Stream Sediment 3-21
  Timber Sales 3-22
  Industrial Processing and Structural Damage 3-23
PRIORITIES AND COST. 3-26

CHAPTER 4 - ACTIVE MINE CLOSURE PROCEDURES 4- 1

GENERAL PROCEDURES FOR ALL MINES 4- 3
SURFACE MINE CLOSURE PROCEDURES 4- 4
    Selected Mining Methods 4- 4
        Trash and Toxic Material Disposal 4- 4
        Cover Excavations 4- 5
        Surface Preparation 4- 6
        Special Cases 4- 7
        Dredging Operations 4- 8
UNDERGROUND MINE CLOSURE PROCEDURES 4- 9
    Procedures within Mine Workings. 4- 9
    Procedures at the Mine Extremities or Surface 4-11

LIST OF TABLES
Section I

Table		Page
1–1	Land Utilized and Reclaimed by the Mining Industry (1930–1971), By State	1–15
1–2	Land Utilized and Reclaimed by the Mining Industry (1971), By State and Commodity Group	1–19
1–3	Land Utilized by the Mining Industry for Selected Commodity (1930–1971), By State	1–22
1–4	Land Utilized by the Mining Industry (1930–1971), By State and Function	1–24
1–5	Land Reclaimed by the Mining Industry (1930–1971), By State and Function	1–26
1–6	Aquatic Resources Adversely Affected by Surface Mining	1–29
1–7	Aquatic Resources Adversely Affected by Coal Mining, By State	1–32
1–8	Projects to Reclaim Mined Land for Improvement of Fish, By State	1–35
1–9	Evaluation of Reclamation Needed for Improvement of Aquatic Habitats, By State	1–36
1–10	Comparison of Primary Demand and Production for 1970, 1985, and 2000, By Commodity	1–42
1–11	Estimated Reserves and Resources, By Commodity	1–43
1–12	Comparison of Primary Demand and Production Values for 1970, 1985, and 2000, By Commodity	1–44
1–13	Crude Ore and Total Material Handled at Surface and Underground Mines, (1972), By Commodity	1–47
1–14	Crude Ore Handled at Surface and Underground Mines, (1972) By State	1–48
3–1	Mined Land Utilization Potential	3– 9
3–2	Recommended Water Quality in the Textile Industry	3–26
3–3	Effectiveness and Related Cost for Various Abatement Techniques	3–28

LIST OF FIGURES
SECTION I

Figure		Page
1-1	Geographic Map of Lands Utilized by Mining	1-14
1-2	Geographic Map of Lands Reclaimed	1-14
1-3	Land Utilized by Mining, by Commodity, 1930 - 1971 and 1971	1-21
1-4	The Role of Minerals in the United States Economy	1-39

A 16

MINING

MINING METHODS

Mining and agriculture are the two basic industries which have led to the development of modern civilization. While agriculture chiefly provides us with food and some clothing materials, mining supplies us with structural materials (such as stone, glass sand, and clays), fuels (coal, petroleum, natural gas), fertilizers (potash, phosphates, nitrates), commercial metallic ores (gold, silver, copper, iron ore, aluminum, lead, zinc), assorted non-metallic commodities (salt, mica, barite, borates, feldspar) and fissionable materials for defense and energy development (uranium, radium, thorium). Two basic mining methods are employed in order to extract these materials - surface and underground. Basic factors involved in determining types of mining method utilized for a particular mineral deposit are grade of ore, physical character of ore deposit, and associated stripping ratio (ratio of overburden thickness to mineral thickness). Depending upon thickness, continuity, slope and quality of the seam, type and conditions of overburden encountered, size of mine area, and return per ton of ore mined, this ratio can be as high as 30:1 and still permit a profitable surface operation where possible. Surface mining is preferred over underground methods because of its higher mineral recovery, much greater production per man day, more economical operation in terms of capital costs and cost per unit, better health and safety conditions, and more flexibility of operation. However, when physical limitations of excavating equipment or economic feasibility of extracting the mineral are surpassed, underground methods are employed.

Surface

Open Pit

Surface mining is accomplished by extracting a mineral from the ground by first removing the overburden (topsoil, subsoil, rock and other strata) which lies above it. Open pit mining, the most commonly used surface mining method (See Appendix A, Table A-1),

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employs various sizes of shovels, draglines and bucket wheel or chain excavators for excavation purposes. It entails drilling, blasting, and removal of overburden (usually a proportionately small quantity when compared to the amount of ore) in order to expose the deposit, followed by extraction of the ore. A large enclosed hole in the earth usually results from this process. The size of the resulting pit varies with commodity mined; minerals which occur in massive deposits at or near the surface, such as copper and iron ore, have reached dimensions measured in thousands of meters, while those which have deposits of a smaller scale, like stone, sand and gravel, and clays, encompass much less area and result in relatively shallow excavations or quarries. As mining proceeds and the open pit becomes deeper, the sides must necessarily be extended outward to accomodate slope stability, preventing rock infalls. In larger operations, waste and ore is usually loaded by shovel or dragline into large haulage trucks, railroad cars, or a combination of both, which travel up spiral benches to the surface. Mobile beneficiation plants are also available to concentrate ore for further processing, and to dispose of waste at the site of excavation (directly into the cut). Experimentation with front-end loaders and conveyor-belt systems is now being conducted. The abovementioned equipment is generally used for smaller quarries, with varied options including the use of mobile cranes for flat-lying deposits, skip systems, cable-suspended buckets, and pipeline water transport.

Area Strip

Area mining is another surface mining technique practiced in relatively flat or slightly rolling terrain. Its use is generally restricted to a few minerals - coal, phosphate, clays, and brown iron ore (See Appendix A, Table A-1). Excavating equipment utilized includes shovels, draglines, bucket wheel or chain excavators, front-end loaders, pan scrapers, and dozers. Initially, a rectangular cut or trench is excavated into the overburden in order to expose the ore deposit, casting overburden to one side. This process is continued with successive parallel cuts being executed until all reserves in the area are mined; spoil from each cut being deposited into the cut just previously made. The final cut is bordered by a spoil bank on one side and a highwall on the other. This results in a gigantic "washboard effect" comprised of ridges and valleys of spoil material. Mineral transport is provided by off-highway vehicles, haulage trucks, rail or conveyor belt.

Contour Strip

Conventional contour strip mining, a technique characterized by widespread use in hilly and mountainous coal regions of Appalachia and phosphate regions of the West (See Appendix A, Table A-1), is initially established with a cut where the mineral is exposed or outcrops. Successive cuts are performed into the hill or mountain, discontinuing the operation at a specific stripping ratio, the point where it is no longer economically feasible to further remove overburden. This stripping ratio compares overburden thickness to mineral thickness, with the limit being determined in some instances by physical limitations of the excavating equipment. In this identical mining manner, strip cuts are continued along the hillside, following the contour of the coal outcrop. The main excavators are shovels, draglines, dozers, and front-end loaders. The result of contour stripping is a long sinuous band of strip mined land around an entire hillside or mountain; a band characterized by a bench or shelf where the coal has been removed, bordered on the inside by a highwall and on the outer, downslope side by indiscriminately-cast piles of spoil material. Mineral transport is provided by truck, rail, or conveyor belt haulage. Several alternative contour methods are presently being employed in order to minimize environmental damages: haulback or lateral movement, mountain-top removal, box-cut, and blockcut.

Auger

Auger mining, a technique often employed in conjunction with contour stripping (although it can also be operated underground), utilizes large cutting heads (up to 2.1 meters or 7 feet in diameter) which operate on a principle similar to drilling; these cutting heads can horizontally bore into the mineral seam (in lengths up to 60 meters or 200 feet), reaming out the mineral at a rate as high as 32 metric tons (or 35 tons) per minute. Augering is used when the stripping ratio for contour mining is too large to permit economical recovery of the mineral.

Dredge

Dredging is a surface method used mainly in extracting gold and sand and gravel (See Appendix A, Table A-1). The dredge is a combination floating barge and excavating machine. This machine has an option to employ various excavating devices, including suction, ladder or chain buckets, clamshells, and draglines. Dredging is a floating open-pit mining process which excavates material on one side of a pond, while rejecting waste on the other side, transporting the pond along with the dredge. Dredges do not always operate in natural bodies of water; they sometimes construct their own artificial ponds.

Hydraulic

An outdated and seldom used method of mining unconsolidated placer deposits of gold, clay, and peat (See Appendix A, Table A-1), hydraulic mining consists of "loosening and disintegrating in-place material by water delivered under pressure through a hydraulic giant, followed by transport with water into a downgrade channel." After the ore-bearing material is eroded by a powerful jet of water, it is usually sluiced through troughs where the desired ore is concentrated and separated from tailings by specific gravity.

In Situ

There are a few specialized in situ mining methods which are important to the mineral industry: the Frasch process, solution mining, and in situ oil shale combustion.

A specialized technique for extraction of sulfur from salt domes is the Frasch process (See Appendix A, Table A-1). It entails deep well extraction of sulfur by melting subsurface deposits by injection of super-heated steam and then pumping molten sulfur to the surface for cooling. After the sulfur has cooled (in huge vats with dimensions of over a hundred meters square and up to 35 meters thick), it is fragmented by means of power shovels for shipping purposes.

Solution mining has limited use in extraction of salt, potash, and copper ore (See Appendix A, Table A-1). Acid leaching with sulfuric acid is sometimes employed with copper ores and, when the ore is enclosed by limestone gangue, an alternative solvent is ammonia (an alkaline reagent). Water leaching is sometimes adopted for underground salt and potash deposits where artificial brines are produced by pumping water through wells into mineral-bearing strata. In solution mining, the desired mineral commodity is generally obtained through chemical precipitation (copper) or solar evaporation of its solvent (water for salt, sulfur, and potash).

An in situ mining process is presently being proposed for commercial extraction of oil shales. In this technique, boreholes are drilled into the strata; the shale is fractured by either hydraulic shock or explosives; the shale is ignited and permitted to burn along a prepared path; shale oil gases are emitted from the combustion process; these liberated gases are recovered from boreholes drilled specifically for that purpose; and the oil is obtained by a liquefaction process using water to cool the escaped gases. A process similar to this has been proposed for "mining" coal deposits, with collection of resultant methane gas.

Underground

Stoping Methods

Underground mining methods are many and varied. Selection of the proper stoping (ore extraction) method entails several factors:

- Health and safety considerations
- Mineral market economics
- Availability and suitability of equipment
- Grade (quality) of the ore
- Shape, horizontal area, volume, regularity, continuity, dip and/or pitch of the ore body
- Depth and type of overburden
- Strength of ore and surrounding rock
- Water and drainage requirements

- Resultant set of local conditions expected after ore extraction
- Topography and climate

Therefore, categorization of mines can be attained by classifying them according to type of related stope (shape and support) - a stope is the resultant open space or chamber after ore extraction. Using this system, all methods of ore extraction can be classified as either supported stopes or caved stopes. A supported stope is one in which the walls and roof are not permitted to cave, supported either naturally or artificially; a caved stope is one in which the walls and roof are forced to cave.

Supported Stopes - Natural

Naturally-supported stopes are those which stand open because of natural support or through artificial aid of ore pillars, rock walls, and occasional posts. The methods in this category are open stoping (open stopes in small ore bodies and sublevel stoping - both applicable to small, irregular deposits and very narrow, steeply-pitching veins), and open stopes with pillar supports (panel, random pillars, and room pillar - mainly applicable to thin, flat-lying beds). This method is generally restricted to hardrock mines with associated strong walls. Such methods may be irregular in form with no definite stoping system followed. Several mineral commodities such as coal, iron ore, copper, potash, phosphate rock, manganese, salt, and uranium (See Appendix A, Table A-1), are mined by these methods.

Supported Stopes - Artificial

Artifically-supported (filled) stopes are those methods which employ waste fill for permanent support. Three general methods are related to this category: shrinkage stoping, square-set stoping, and cut-and-fill,stoping. These methods, especially square-set and cut-and-fill, are particularly adaptable to irregular ore deposits. Such filled stoping methods are generally applied to medium and soft rock deposits of high grade ore. The mining process incorporated into these methods follows a more regular pattern in mining out sections than does that of naturally-supported methods. Mineral commodities mined by artificially-supported stoping include lead, zinc, mercury, and gypsum (See Appendix A, Table A-1).

Caved Stopes

Caved stopes are those methods which employ caving the back or capping as mining progresses. No waste fill nor any other form of support is used. Three general steps comprise this technique: 1) natural supports are removed from beneath the ore by undercutting a section through drilling and blasting procedures; 2) the ore block and/or overburden undercut is permitted to cave, allowing nature to assist in breaking up and crushing the ore; 3) the broken ore is either fed into chutes or finger raises (vertical shafts previously drilled underneath the ore body which interconnect with a main haulageway), or extracted by means of horizontal drifts cut into the ore body. The methods include:

- Block caving - primarily applicable to large ore bodies having extensive lateral and vertical dimensions with associated weak capping;
- Sublevel stoping - mainly applicable to irregular veins which are narrow and flat dipping or veins which are nearly vertical (both requiring weak walls);
- Top slicing - applicable to flat ore bodies, narrow veins with weak walls, irregular ore bodies, and old previously - stoped areas (all of which need an associated weak capping).

Various combinations of supported and caved stopes (such as shrinkage stoping with pillar caving or cut-and-fill stoping with top slicing) - generally applicable to both large ore bodies, as well as narrow and wide veins, where the ore is hard, firm and blocky, or strongly packed together are also employed. Caving systems are most applicable to large, low-grade copper, lead, and molybdenum deposits (See Appendix A, Table A-1), where the ore is homogeneous and may properly be classified as soft or medium. When compared to natural or artificial supporting methods, caving techniques are much more highly standardized with a defined system generally being followed.

Conventional

Two predominant mineral extraction procedures are currently employed in American underground mines - conventional and continuous mining. The sequence of events usually incorporated into conventional mining are 1) undercutting or overcutting the mineral seam with a mechanized "cutter" to permit expansion of the mineral upon blasting, while minimizing damage to the roof rock; 2) horizontally drilling the mineral at predetermined intervals to enable placement of explosives and blasting; 3) breakage of the mineral by either explosives or high pressure air; 4) loading and transporting the mineral from the working face; and 5) roof bolting or timbering to support overburden material where the mineral has been removed.

Continuous

Conventional mining as described above may gradually be replaced by continuous mining equipment. A "continuous miner" is a single mechanized unit which breaks or cuts the mineral directly from the working face and loads it into a transporting system. At present, continuous miners are restricted to soft ores, like coal. By using these miners, the separate equipment and operating personnel used in the conventional mining phases of cutting, drilling, and blasting are eliminated. Transportation from the working face to mine portals varies considerably from mine to mine. The following or various combinations thereof are currently being employed: 1) primary haulage - electric rail, conveyor belt systems, load-haul-dump (LHD's) and hydraulic transport systems; 2) secondary haulage - shuttle cars, loading machines, scrapers and gravity flow.

Longwall - Shortwall

The most automatic and efficient of mining methods is longwall mining, a caving method which has been adapted for coal mining. Due to its advanced technology, longwall mining is distinctly different from its counterpart caving methods. The production potential of longwall mining is approximately three times that of conventional and two times continuous miner units. It is generally restricted to seams

0.9 to 2.1 meters (3 to 7 feet) thick which are consistent and fairly level. The principal cutting machine employed can be a device with fixed cutting blades call a "plow" or one with rotating drums called a "shearer". The process consists of cutting the coal by passing the plow or shearer along a track, over the mineral face; the severed mineral then falls or is pushed into an armored chain conveyor running parallel to the track. The roof is supported by a long line of hydraulically-operated steel roof jacks that are either a chock or frame type inserted along the working face to preserve roof integrity. As mining progresses, the chocks are advanced into the cut area, allowing the roof to collapse behind them. The face of the longwall mine is typically 90 to 245 meters (300 to 800 feet) long. Shortwall mining is a modification of longwall which employs a continuous miner, rather than a plow or shearer, over a shorter length of working face. Rather than using the typical armored chain conveyors of longwall mining, the shortwall systems generally utilize various types of continuous conveyor trains in tow.

Entryways

Associated with each of these mining methods is the type of entryway. Drift mines, the cheapest method of access to underground mines, enter the mineral at an outcrop. They provide nearly horizontal access to mine workings and may be subdivided into up-dip versus down-dip classifications. Up-dip drifts are those which mine the mineral seam to the rise, thus utilizing gravity assistance for mineral haulage, while down-dip drifts are those which mine the seam to the dip and require mechanical means of mineral haulage. Slope mines are employed where the outcrop condition is unsafe or unsatisfactory for drift entry or where the mineral seam lies at an intermediate depth. They are associated with an inclined slope entry driven to the mineral seam from the land surface above. Shaft mines are utilized where the mineral lies too far below the surface to outcrop or the lengths of slopes are economically excessive; vertical entryways are driven to the mineral seam and elevators employed to provide access to the workings.

MINERAL COMMODITIES MINED IN THE UNITED STATES

The mineral industry of the United States annually produces 80 mineral resources to help fulfill the needs of our industrialized society. Its extent and significance are far-reaching, affecting our entire way of life. In 1972, domestic production of primary minerals and mineral fuels was valued at $32.2 billion. Further, mineral production is expected to grow in value at an annual rate of 1.8%, with a quantitative increase of 4% to the year 2000. Therefore, the economy of all the states should become ever more dependent upon the industry.

The scope of the mineral industry varies greatly from state to state: mineral production ranging from a low of $2,871,000 for Delaware to a high of $7,211,551,000 for Texas; a per square kilometer value from $188,000 for Alaska to a high of $43,060,000 for Louisiana; and a per capita value from a low of $5 for Rhode Island to a high of $2,249 for Wyoming (all include petroleum and natural gas values). See Appendix A, Table A-2. In order to appraise the extent and impact of the mineral industry upon each of the states, Table A-3 (Appendix A) has been included.

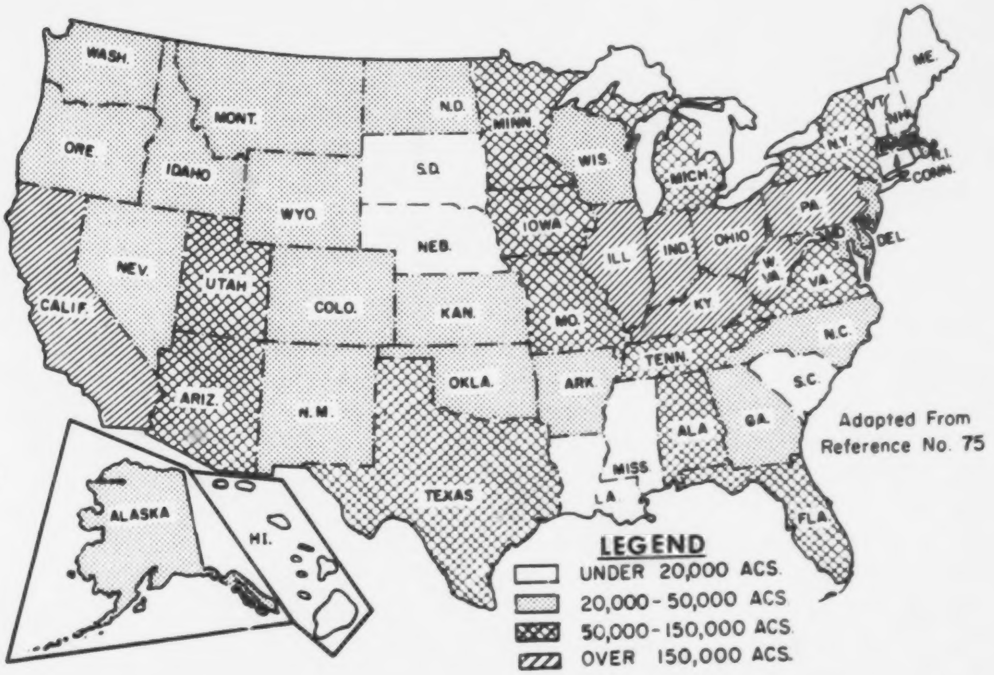
Table A-4 (Appendix A) presents a breakdown of mineral production by commodity and affected states.

An important indicator of the type, extent, and intensity of effects (especially economical and environmental) generated by mineral extraction is the size of producing mines. For a characterization of the industry refer to Table A-5 (Appendix A) which delineates, by commodity, the number of mines falling within various categories of size.

AREAS UTILIZED AND RECLAMATION BY THE MINERAL INDUSTRY

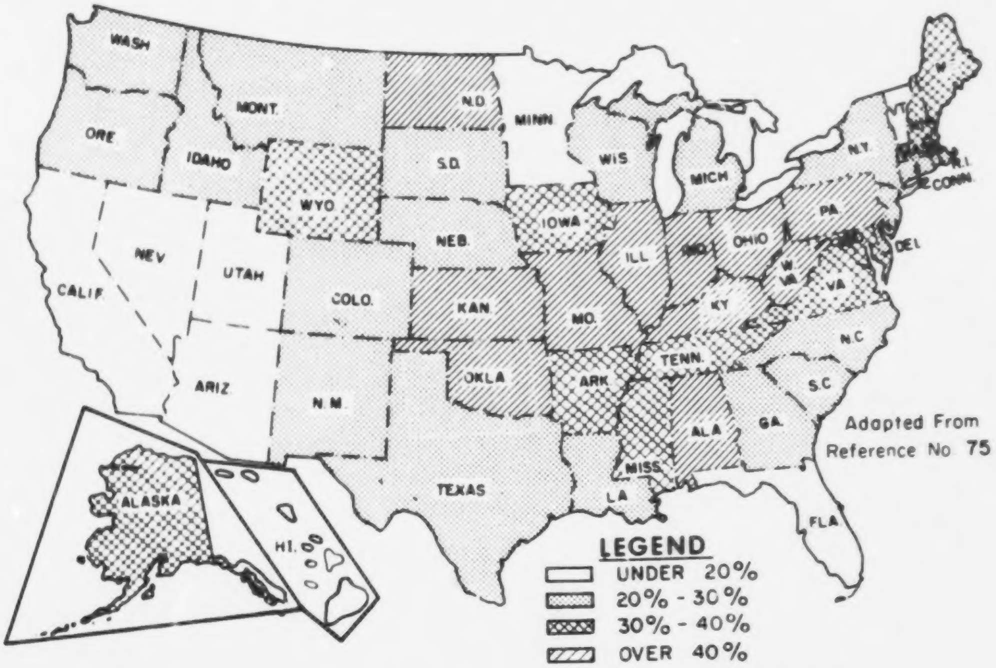
Relative to other types of land use, mineral extraction is minor. From 1930-1971, mineral extraction has only utilized 0.16% (1.48 million hectares or 3.65 million acres) of the total land mass of the United States, whereas forest land comprises 32% - 292 million hectares (721 million acres), pasture and range land 27% - 244 million hectares (604 million acres), croplands 21% - 191 million hectares (472 million acres), National Parks 1.3% - 12 million hectares (29.6 million acres), and highways 1% - 9.2 million hectares (22.7 million acres) (75). In addition, the impact of mined land utilization has been reduced through reclamation efforts affecting approximately 0.59 million hectares (1.46 million acres or 40% of total area utilized during 1930-1971 -- See Figures 1-1 and 1-2). About half of these reclamation efforts were performed on bituminous coal mined land.

Since mineral extraction is practiced in each of the fifty states, Table 1-1 has been included to show, on a state by state basis, the total acreages and associated percentages of land utilized and reclaimed during 1930-1971 by mining operations. The following paragraph summarizes in metric units only, the contents of Table 1-1. The major coal-producing states account for the largest total areas utilized by mining operations, as well as largest percentages of total state land area utilized: Pennsylvania (154,000 hectares utilized -- 1.32%), Illinois (120,000 hectares utilized -- .83%), Ohio (118,000 hectares utilized -- 1.11%), Kentucky (95,000 hectares utilized -- .92%), and West Virginia (85,000 hectares utilized -- 1.36%). In contrast, there are states whose mineral industries have utilized a much smaller amount of land and have also affected a much smaller percentage of their total land area: Maine (4,200 hectares -- 0.05%), Nebraska (5,200 hectares -- 0.03%), South Dakota (6,700 hectares -- 0.03%), Wyoming (11,500 hectares -- 0.05%), and Alaska (12,000 hectares -- 0.01%). In general, coal-producing states have also reclaimed the greatest amount of land and have had the largest associated percentages of disturbed land reclaimed: Pennsylvania reclaimed 75,300 hectares (48.8%), Illinois reclaimed 76,100 hectares (63.3%), Ohio reclaimed 73,300 hectares (62.0%), Kentucky reclaimed 60,700 hectares (50.0%). However, notable metal-producing states performed relatively little reclamation: Arizona (2,770 hectares -- 6.7%), Utah (2,590 hectares -- 9.6%), and Minnesota (5,260 hectares -- 9.6%). Basically, this is because most mines are either presently still in operation or are considered potentially-mineable in the future due to expected technological advances. These advances are expected to make mining of lower grade ores economically feasible. From 1930-1971, the fossil fuels industry reclaimed 64% of the land it utilized, the nonmetallic industry reclaimed 26% of its land, and the metal industry reclaimed only 8% of its land. However, in 1971, the fossil fuel industry actually reclaimed more land than utilized (129%), while the nonmetallic and metallic



Adapted From Reference No. 75

Figure 1-1. Geographic map of lands utilized by mining.



Adapted From Reference No. 75

Figure 1-2. Geographic map of lands reclaimed.

Table 1-1

LAND UTILIZED AND RECLAIMED BY THE MINING INDUSTRY (1930-71), BY STATE

STATE	Percent of total land area used for mining	Total area utilized[1] (acres)	Total area reclaimed[1] (acres)	Percent reclaimed
ALABAMA	0.20	65,100	28,500	43.8
ALASKA	.01	29,600	10,600	35.8
ARIZONA	.14	102,000	6,850	6.7
ARKANSAS	.09	29,500	9,040	30.6
CALIFORNIA	.23	227,000	43,900	19.3
COLORADO	.07	48,800	14,000	28.7
CONNECTICUT	.39	12,300	3,410	27.7
DELAWARE	.10	1,330	370	27.8
FLORIDA	.26	88,800	17,100	19.3
GEORGIA	.09	34,300	9,650	28.1
HAWAII	.12	4,810	1,160	24.1
IDAHO	.08	41,300	8,660	21.0
ILLINOIS	.83	297,000	188,000	63.3
INDIANA	.76	175,000	113,000	64.6
IOWA	.15	55,300	18,300	33.1
KANSAS	.08	44,000	21,500	48.9

Adapted From Reference No. 75

Table 1-1 Continued

STATE	Percent of total land area used for mining	Total area utilized^1 (acres)	Total area reclaimed^1 (acres)	Percent reclaimed
KENTUCKY	.92	234,000	150,000	64.1
LOUISIANA	.06	18,200	5,210	28.6
MAINE	.05	10,500	3,170	30.2
MARYLAND	.41	25,600	9,170	35.8
MASSACHUSETTS	.40	20,300	5,610	27.6
MICHIGAN	.27	99,500	24,100	24.2
MINNESOTA	.27	136,000	13,000	9.6
MISSISSIPPI	.04	10,700	3,310	30.9
MISSOURI	.23	102,000	41,400	40.6
MONTANA	.05	42,800	10,600	24.8
NEBRASKA	.03	12,800	3,720	29.1
NEVADA	.06	41,100	4,020	9.8
NEW HAMPSHIRE	.09	5,300	1,590	30.0
NEW JERSEY	.59	28,400	7,470	26.3
NEW MEXICO	.06	47,800	9,800	20.5
NEW YORK	.31	96,300	24,600	25.5
NORTH CAROLINA	.12	36,600	9,640	26.3
NORTH DAKOTA	.08	35,100	23,900	68.1
OHIO	1.11	292,000	181,000	62.0
OKLAHOMA	.08	35,500	16,500	46.5
OREGON	.06	34,000	8,940	26.3

Adapted From Reference No. 75

Table 1-1 Continued

STATE	Percent of total land area used	Total area utilized[1] (acres)	Total area reclaimed[1] (acres)	Percent reclaimed
PENNSYLVANIA	1.32	381,000	186,000	48.8
RHODE ISLAND	.34	2,330	540	23.2
SOUTH CAROLINA	.07	14,500	4,110	28.3
SOUTH DAKOTA	.03	16,500	4,650	28.2
TENNESSEE	.25	67,800	23,400	34.5
TEXAS	.05	78,000	20,500	26.3
UTAH	.13	66,700	6,390	9.6
VERMONT	.12	7,380	1.200	16.3
VIRGINIA	.31	78,800	28,900	36.7
WASHINGTON	.08	35,900	9,740	27.1
WEST VIRGINIA	1.36	210,000	105,000	50.0
WISCONSIN	.13	46,900	12,400	26.4
WYOMING	.05	28,300	8,890	31.4
TOTAL	.16	3,650,000	1,460,000	40.0

Adapted From Reference No. 75

[1] Includes area of surface mine excavation, area used for disposal of surface mine waste, surface area subsided or disturbed as a result of underground workings, surface area used for disposal of underground waste, and surface area used for disposal of mill or processing waste.

groups reclaimed 56% and 35%, respectively. For an examination of this latest trend, refer to Table 1-2 which gives a breakdown by state of the acres utilized and reclaimed by the fossil fuel, nonmetallic, and metallic mineral industries in 1971.

For an analysis of the land utilized and reclaimed by the major mineral commodities, see Figure 1-3. During the period 1930-1971, the most significant mineral commodities in terms of land utilized are, in decreasing order of importance: bituminous coal, sand and gravel, stone, clay, copper, iron ore, and phosphate rock. The only variance in this order of commodities for land reclaimed is that phosphate rock directly precedes copper and iron ore (metals which are mainly mined by the open pit method). The trend, if 1971 figures are truly indicative of such, has changed somewhat the prominence of the various minerals (See Figure 1-3). Table 1-3, delineates on a state by state basis the total number of acres utilized (by the mining industry during the period of 1930-1971) by commodity.

A characterization of acreages utilized and reclaimed by surface and underground mining methods by state is shown in Table 1-4 and 1-5. Of the 1.48 million hectares (3.65 million acres) utilized by the mining industry approximately 80% is associated with surface mining, 8% with underground mining, and 12% with milling waste areas; whereas surface mining accounted for 95%, underground mining 2%, and milling waste area 3% of the 0.59 million hectares (1.46 million acres) reclaimed by the industry.

WATERWAYS AFFECTED BY THE MINERAL INDUSTRY

Unfortunately, the extent of damage caused by the mineral industry to our public waterways has not been specifically defined. Even if major surveys are implemented to identify mine drainage effluents, it will be difficult, to determine the exact amount of drainage emanating from various categories of mines. This is due to intermingling of effluents from more than one source. Our waterways are affected not only by surface and underground mines, but also by associated milling processes and natural seepage from unworked pyritic minerals. Detection and measurement of drainage entering underground waters presents another problem situation to be resolved.

When measured in terms of fish killed by mining operations, the mineral industry has contributed minimally to the pollution of our

Table 1-2

LAND[1] UTILIZED AND RECLAIMED BY THE MINING INDUSTRY (1971), BY STATE AND COMMODITY GROUP

STATE	AREA IN ACRES							
	METALS		NONMETALS		FOSSIL FUELS		TOTAL	
	Utilized	Reclaimed	Utilized	Reclaimed	Utilized	Reclaimed	Utilized	Reclaimed
ALABAMA	180		1,000	590	3,170	2,160	4,360	2,930
ALASKA	130	390	680	490	210	750	1,020	1,630
ARIZONA	10,900	670	2,260	650	W	W	13,200	1,320
ARKANSAS	140	80	1,120	900	150	170	1,420	1,150
CALIFORNIA	1,760	2,060	10,300	6,610	W	W	12,000	8,670
COLORADO	300	340	4,460	970	380	470	5,140	1,780
CONNECTICUT	-	-	540	400	-	-	540	400
DELAWARE	-	-	200	60	-	-	200	60
FLORIDA	890	120	11,000	2,240	20	4	11,900	2,360
GEORGIA	410	180	1,930	1,030	1	1	2,340	1,210
HAWAII	-	-	330	80	-	-	330	80
IDAHO	360	1,000	1,070	560	W	W	1,430	1,560
ILLINOIS	W	W	3,710	2,410	7,600	12,900	11,300	15,300
INDIANA	-	-	2,090	1,340	4,350	8,030	6,440	9,380
IOWA	-	-	1,620	1,320	120	420	1,740	1,740
KANSAS	-	240	1,170	760	W	W	1,170	1,010
KENTUCKY	W	W	950	540	13,500	14,100	14,500	14,600
LOUISIANA	-	-	1,230	670	-	-	1,240	670
MAINE	W	W	650	580	50	50	700	630
MARYLAND	-	-	1,210	740	250	370	1,460	1,110
MASSACHUSETTS	-	-	1,450	850	W	-	1,450	850
MICHIGAN	960	180	3,840	2,660	100	150	4,900	3,000
MINNESOTA	5,400	1,640	2,130	1,550	W	W	7,540	3,190
MISSISSIPPI	-	-	700	410	-	-	700	410
MISSOURI	W	W	1,780	1,030	W	W	1,780	1,030
MONTANA	1,510	270	2,070	1,430	740	460	4,320	2,170

Adapted From Reference No. 75

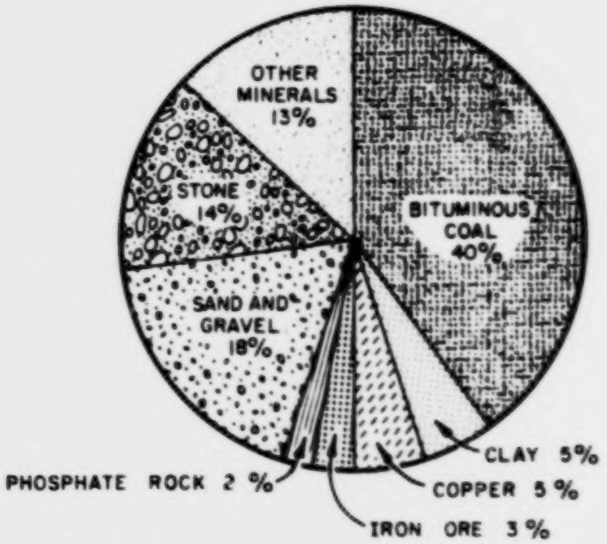
Table 1-2 Continued

STATE	AREA IN ACRES							
	METALS		NONMETALS		FOSSIL FUELS		TOTAL	
	Utilized	Reclaimed	Utilized	Reclaimed	Utilized	Reclaimed	Utilized	Reclaimed
NEBRASKA	-	-	940	620	-	-	940	620
NEVADA	2,190	790	950	440	-	-	3,140	1,230
NEW HAMPSHIRE	-	-	330	240	-	-	330	240
NEW JERSEY	W	W	1,180	970	60	4	1,240	970
NEW MEXICO	790	330	1,000	430	W	W	3,790	750
NEW YORK	360	150	2,330	2,030	20	-	2,710	2,180
NORTH CAROLINA	W	-	2,240	960	-	-	2,240	960
NORTH DAKOTA	-	1	550	420	1,000	1,590	1,550	2,010
OHIO	-	-	3,450	2,740	9,560	13,000	13,000	15,800
OKLAHOMA	W	W	690	490	W	W	690	490
OREGON	20	320	1,620	980	-	1	1,640	1,300
PENNSYLVANIA	110	40	2,510	1,260	11,800	17,900	14,400	19,200
RHODE ISLAND	-	-	180	80	-	-	180	80
SOUTH CAROLINA	-	-	790	510	10	-	800	510
SOUTH DAKOTA	80	20	910	700	-	10	1,000	740
TENNESSEE	W	W	1,560	1,120	2,070	2,050	3,630	3,170
TEXAS	360	250	4,830	2,500	W	W	5,190	2,750
UTAH	3,140	850	990	640	W	W	4,130	1,490
VERMONT	-	110	250	120	-	-	250	240
VIRGINIA	W	W	2,260	1,100	2,900	2,830	5,160	3,930
WASHINGTON	60	60	3,000	1,380	W	W	3,060	1,440
WEST VIRGINIA	-	-	500	350	11,100	12,500	11,600	12,900
WISCONSIN	W	W	2,130	1,540	W	W	2,130	1,540
WYOMING	1,690	190	1,510	740	750	540	3,940	1,460
UNDISTRIBUTED	2,540	2,140	-	-	5,290	6,440	7,870	8,590
TOTAL	36,400	12,600	95,100	53,200	74,800	96,900	206,000	163,000

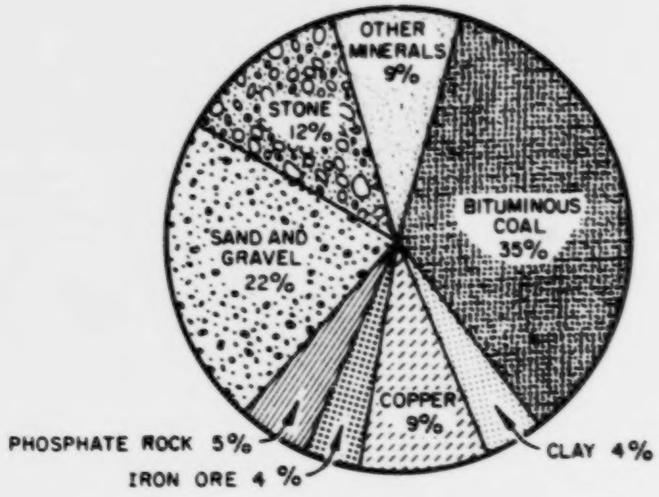
Adapted From Reference No. 75

W Withheld to avoid disclosing individual company confidential data, included with "Undistributed."

[1] Includes area of surface mine excavation, area used for disposal of surface mine waste, surface area subsided or disturbed as a result of underground workings, surface area used for disposal of underground waste, and surface area used for mill or processing waste.



1930-71



1971

Adopted From
Reference No. 75

Figure 1-3. Land utilized by mining, (1930-71 and 1971), by commodity.

Table 1-3

LAND[1] UTILIZED BY THE MINING INDUSTRY

FOR SELECTED COMMODITY (1930-71), BY STATE

STATE	AREA IN ACRES									
	BITUMINOUS COAL	CLAYS	COPPER	IRON ORE	PHOSPHATE ROCK	SAND AND GRAVEL	STONE	URANIUM	ALL OTHER COMMODITIES	TOTAL
ALABAMA	34,900	6,390	-	7,540	-	5,280	10,700	-	280	65,100
ALASKA	3,600	10	220	-	-	9,520	390	10	15,900	29,600
ARIZONA	220	630	84,000	5	-	10,800	2,140	620	3,970	102,000
ARKANSAS	3,100	2,040	-	5	-	8,870	9,580	-	5,950	29,500
CALIFORNIA	30	10,400	-	2,720	-	81,000	31,300	5	101,000	227,000
COLORADO	8,630	1,590	30	50	-	14,700	5,630	330	17,900	48,800
CONNECTICUT	-	830	-	-	-	6,350	4,980	-	150	12,300
DELAWARE	-	80	-	-	-	1,130	120	-	-	1,330
FLORIDA	-	1,710	-	-	47,900	5,970	22,100	-	11,100	88,800
GEORGIA	40	13,700	-	370	-	2,580	15,000	-	2,640	34,300
HAWAII	-	60	-	-	-	520	3,470	-	760	4,810
IDAHO	10	120	30	5	8,220	7,350	2,070	5	23,500	41,300
ILLINOIS	234,000	7,880	-	-	-	31,700	21,900	-	900	297,000
INDIANA	130,000	5,420	-	-	-	19,400	19,200	-	620	175,000
IOWA	8,600	3,390	-	-	-	14,000	25,200	-	4,110	55,300
KANSAS	19,700	2,760	-	-	-	10,100	4,960	-	6,490	44,000
KENTUCKY	210,000	3,740	-	-	-	5,080	14,800	-	270	234,000
LOUISIANA	-	2,460	-	-	-	11,300	4,320	-	120	18,200
MAINE	-	140	-	-	-	9,260	920	-	220	10,500
MARYLAND	4,610	2,550	-	-	-	10,400	7,880	-	190	25,600
MASSACHUSETTS	-	520	-	-	-	13,100	6,680	-	10	20,300
MICHIGAN	560	6,700	4,800	4,770	-	40,500	33,200	-	8,980	99,500
MINNESOTA	-	560	-	80,300	-	28,400	3,880	-	23,100	136,000

Adapted From Reference No. 75

Table 1-3 Continued

STATE	AREA IN ACRES									
	BITUMI-NOUS COAL	CLAYS	COPPER	IRON ORE	PHOS-PHATE ROCK	SAND AND GRAVEL	STONE	URANIUM	ALL OTHER COMMODI-ITIES	TOTAL
MICHIGAN	560	6,700	4,800	4,770	-	40,500	33,200	-	8,980	99,500
MINNESOTA	-	590	-	80,400	-	28,400	3,880	-	23,100	136,000
MISSISSIPPI	-	3,500	-	-	-	6,510	710	-	-	10,700
MISSOURI	33,500	8,790	-	520	-	9,550	22,600	-	27,400	102,000
MONTANA	6,820	900	10,900	10	2,600	12,300	3,310	5	6,500	42,800
NEBRASKA	-	500	-	-	-	9,820	2,510	-	20	12,800
NEVADA	-	30	12,800	540	-	5,830	1,360	10	20,600	41,100
NEW HAMPSHIRE	-	130	-	-	-	4,760	210	-	200	5,300
NEW JERSEY	-	2,100	-	630	-	12,600	9,880	-	3,170	28,400
NEW MEXICO	8,260	230	11,000	30	-	8,950	1,690	6,670	11,000	47,800
NEW YORK	-	4,670	-	1,650	-	30,600	28,300	-	30,900	96,300
NORTH CAROLINA	-	8,200	-	5	190	8,790	14,800	-	4,670	36,600
NORTH DAKOTA	27,200	140	-	-	-	7,540	100	20	10	35,100
OHIO	207,000	17,300	-	-	-	31,300	35,500	-	860	292,000
OKLAHOMA	13,800	2,370	340	-	-	4,810	11,700	-	2,490	35,500
OREGON	20	490	10	-	-	14,000	12,100	20	7,110	34,000
PENNSYLVANIA	247,000	11,700	-	370	-	16,500	6,260	-	98,300	381,000
RHODE ISLAND	-	-	-	-	-	1,540	420	-	370	2,330
SOUTH CAROLINA	-	4,800	-	-	-	3,090	5,540	-	1,100	14,500
SOUTH DAKOTA	110	930	-	5	-	11,400	2,220	250	1,320	16,500
TENNESSEE	17,900	4,430	340	20	16,300	6,420	19,100	-	2,850	67,800
TEXAS	770	11,600	5	1,010	-	27,400	28,800	240	8,130	78,000
UTAH	3,020	840	36,900	5,310	1,090	8,600	3,500	20	7,340	66,700
VERMONT	-	40	200	-	-	1,960	1,410	-	3,780	7,380
VIRGINIA	34,800	1,900	5	10	10	9,100	20,800	-	10,500	78,800
WASHINGTON	7,370	890	110	5	-	14,500	10,400	350	2,330	35,900
WEST VIRGINIA	196,000	1,230	-	-	-	5,030	7,640	-	70	210,000
WISCONSIN	-	440	-	1,740	-	29,900	14,000	-	810	46,900
WYOMING	10,100	3,900	-	1,400	690	5,640	1,850	4,300	440	28,300
TOTAL	1,470,000	167,000	166,000	108,000	17,300	660,000	510,000	12,800	480,000	3,650,000

Adapted From Reference No. 75

[1] Includes area of surface mine excavation, area used for disposal of surface mine waste, surface area subsided or disturbed as a result of underground workings, surface area used for disposal of underground waste, and surface area used for disposal of mill or processing waste.

Table 1-4

LAND UTILIZED BY THE MINING INDUSTRY

(1930-71), BY STATE AND FUNCTION

STATE	AREA IN ACRES					
	SURFACE MINING		UNDERGROUND MINING		MILLING, SURFACE WASTE AREA	TOTAL LAND UTILIZED
	MINED AREA	WASTE AREA	SUBSIDED OR DISTURBED AREA	SURFACE WASTE AREA		
ALABAMA	39,700	12,900	2,080	4,830	5,510	65,100
ALASKA	22,300	3,550	100	60	3,610	29,600
ARIZONA	26,600	34,900	2,910	360	37,600	102,000
ARKANSAS	18,700	6,180	260	290	4,130	29,500
CALIFORNIA	105,000	57,100	2,230	12,200	50,400	227,000
COLORADO	30,200	5,750	1,320	3,310	8,200	48,800
CONNECTICUT	8,730	2,180	-	-	1,390	12,300
DELAWARE	980	230	-	-	130	1,330
FLORIDA	71,500	10,300	-	-	7,040	88,800
GEORGIA	23,600	5,420	10	30	5,240	34,300
HAWAII	3,460	810	-	-	540	4,810
IDAHO	16,700	3,980	520	3,010	17,100	41,300
ILLINOIS	201,000	63,800	6,320	14,600	10,500	297,000
INDIANA	125,000	39,300	1,270	2,930	6,060	175,000
IOWA	38,300	10,100	260	570	6,030	55,300
KANSAS	27,500	7,970	70	150	8,290	44,000
KENTUCKY	146,000	49,000	9,470	22,100	7,030	234,000
LOUISIANA	12,900	3,260	-	10	2,070	18,200
MAINE	7,620	1,900	-	-	1,020	10,500
MARYLAND	17,800	4,760	180	400	2,540	25,600
MASSACHUSETTS	14,600	3,650	-	-	2,100	20,300
MICHIGAN	64,600	17,100	1,590	840	15,300	99,500
MINNESOTA	72,300	37,900	-	-	26,100	136,000

Adapted From Reference No. 75

Table 1-4 Continued

STATE	AREA IN ACRES					
	SURFACE MINING		UNDERGROUND MINING		MILLING, SURFACE WASTE AREA	TOTAL LAND UTILIZED
	MINED AREA	WASTE AREA	SUBSIDED OR DISTURBED AREA	SURFACE WASTE AREA		
MISSISSIPPI	7,680	1,890	-	-	1,140	10,700
MISSOURI	55,300	15,500	180	610	30,700	102,000
MONTANA	22,200	14,100	350	600	5,450	42,800
NEBRASKA	9,170	2,310	-	10	1,360	12,800
NEVADA	12,000	11,100	2,160	2,170	13,700	41,100
NEW HAMPSHIRE	3,750	1,020	-	-	530	5,300
NEW JERSEY	16,500	4,590	210	100	5,000	28,400
NEW MEXICO	19,600	13,900	4,310	2,140	7,840	47,800
NEW YORK	55,800	12,600	190	190	27,400	96,300
NORTH CAROLINA	24,100	6,550	-	-	6,020	36,600
NORTH DAKOTA	25,700	8,350	70	150	770	35,100
OHIO	206,000	63,400	2,960	6,860	12,600	292,000
OKLAHOMA	24,800	6,900	130	300	3,410	35,500
OREGON	22,100	5,290	-	-	6,600	34,000
PENNSYLVANIA	221,000	64,500	35,600	43,600	16,500	381,000
RHODE ISLAND	1,730	370	-	-	220	2,330
SOUTH CAROLINA	9,840	2,300	-	-	2,390	14,500
SOUTH DAKOTA	10,900	2,980	100	120	2,420	16,500
TENNESSEE	40,500	12,300	1,430	2,200	11,300	67,800
TEXAS	54,000	13,300	520	570	9,650	78,000
UTAH	18,900	19,200	920	2,200	25,500	66,700
VERMONT	2,870	860	-	30	3,630	7,380
VIRGINIA	42,600	13,100	3,620	8,410	11,100	78,800
WASHINGTON	24,500	6,470	260	400	4,350	35,900
WEST VIRGINIA	96,500	30,600	22,200	51,800	8,770	210,000
WISCONSIN	32,300	8,730	60	30	5,780	46,900
WYOMING	14,800	9,040	620	1,450	2,410	28,300
TOTAL	2,170,000	733,000	105,000	190,000	454,000	3,650,000

Adapted From Reference No. 75

Table 1-5

LAND RECLAIMED BY THE MINING INDUSTRY

(1930-71), BY STATE AND FUNCTION

STATE	AREA IN ACRES					
	SURFACE MINING		UNDERGROUND MINING		MILLING, SURFACE WASTE AREA	TOTAL LAND RECLAIMED
	MINED AREA	WASTE AREA	SUBSIDED OR DISTURBED AREA	SURFACE WASTE AREA		
ALABAMA	19,100	8,210	80	580	600	28,500
ALASKA	7,850	1,940	-	10	850	10,600
ARIZONA	3,450	1,940	70	-	1,550	6,850
ARKANSAS	5,290	3,230	30	40	450	9,040
CALIFORNIA	23,800	13,000	370	640	6,060	43,900
COLORADO	9,470	3,160	130	310	950	14,000
CONNECTICUT	2,080	1,130	-	-	200	3,410
DELAWARE	250	100	-	-	20	370
FLORIDA	12,500	4,030	-	-	530	17,100
GEORGIA	6,230	2,980	-	10	430	9,650
HAWAII	620	480	-	-	60	1,160
IDAHO	4,710	1,560	100	280	2,020	8,660
ILLINOIS	133,000	51,600	280	1,730	1,820	188,000
INDIANA	80,300	31,500	50	350	960	113,000
IOWA	11,500	5,960	10	70	740	18,300
KANSAS	14,900	5,710	10	30	800	21,500
KENTUCKY	104,000	41,600	350	2,630	1,300	150,000
LOUISIANA	3,320	1,570	-	-	320	5,210
MAINE	2,170	810	-	-	190	3,170
MARYLAND	5,980	2,770	10	50	360	9,170
MASSACHUSETTS	3,530	1,750	-	-	340	5,610
MICHIGAN	14,300	8,050	-	90	1,610	24,100
MINNESOTA	7,250	4,050	-	-	1,680	13,000
MISSISSIPPI	2,280	850	-	-	180	3,310

Adapted From Reference No. 75

Table 1-5 Continued

STATE	AREA IN ACRES					
	SURFACE MINING		UNDERGROUND MINING		MILLING, SURFACE WASTE AREA	TOTAL LAND RECLAIMED
	MINED AREA	WASTE AREA	SUBSIDED OR DISTURBED AREA	SURFACE WASTE AREA		
MISSOURI	26,500	11,300	10	200	3,340	41,400
MONTANA	6,500	3,220	80	150	650	10,600
NEBRASKA	2,430	1,060	-	-	230	3,720
NEVADA	1,720	890	360	50	1,000	4,020
NEW HAMPSHIRE	1,070	420	-	-	100	1,590
NEW JERSEY	4,470	2,300	150	-	550	7,470
NEW MEXICO	6,110	3,240	10	50	390	9,800
NEW YORK	16,900	6,190	130	20	1,370	24,600
NORTH CAROLINA	5,810	3,280	-	-	560	9,640
NORTH DAKOTA	17,100	6,610	-	20	160	23,900
OHIO	128,000	50,400	120	840	1,880	181,000
OKLAHOMA	11,400	4,700	10	40	390	16,500
OREGON	5,100	2,660	-	-	1,180	8,940
PENNSYLVANIA	131,000	45,600	2,140	5,470	2,060	186,000
RHODE ISLAND	340	170	-	-	30	540
SOUTH CAROLINA	2,650	1,260	-	-	200	4,110
SOUTH DAKOTA	3,050	1,280	30	10	280	4,650
TENNESSEE	14,800	7,230	190	250	920	23,400
TEXAS	12,800	6,420	80	20	1,260	20,500
UTAH	2,970	1,430	40	290	1,560	6,390
VERMONT	580	330	-	10	280	1,200
VIRGINIA	18,400	8,460	140	1,010	900	28,900
WASHINGTON	6,020	3,000	50	50	630	9,740
WEST VIRGINIA	70,000	25,900	800	6,170	1,960	105,000
WISCONSIN	7,550	3,970	40	-	840	12,400
WYOMING	5,440	3,070	20	120	240	8,890
TOTAL	987,000	402,000	5,870	21,600	47,100	1,460,000

Adapted From Reference No. 75

waters. In 1969, mining operations were responsible for only 4% of the total reports and 1% of the total fish actually killed from pollutional sources; whereas industrial sources accounted for 39% and 69%, agricultural sources accounted for 25% and 15%, municipal sources accounted for 18% and 3%, and transportation sources accounted for 7% and 5% of the total reports and fish killed, respectively.

Although little information is available on pollutional sources from underground mines, some studies have been done on the effects of surface operations on our aquatic resources. By 1965, total aquatic resources adversely affected by physical, chemical, and biological changes produced by surface mining operations were quite extensive: approximately 21,000 kilometers (13,000 miles) of stream; 40,500 surface hectares (100,000 acres) of natural lakes; and 17,000 surface hectares (42,000 acres) of reservoirs and impoundments were thus affected (See Table 1-6). Of 11,300 kilometers (7,000 miles) of stream channels which have been reduced in size by sedimentation from surface mines (primarily stone, clay, coal, and sand and gravel operations) about 7,240 kilometers (4,500 miles) were moderately to severely affected, while 4,000 kilometers (2,500 miles) were only slightly affected (normal capacity having been reduced by less than 1/3). However, the greatest mineral water pollution problem exists east of the Mississippi River where coal mining is predominant. Of the total 21,000 kilometers (13,000 miles) of stream adversely affected by surface operations, almost 9,700 kilometers (6,000 miles) were contaminated by coal mining (See Table 1-7).

Little information is attainable defining the extent of different types of mine drainage, however, there exists a considerable amount of data on acid mine drainage associated with coal mining operations. Although acid mine drainage is normally associated with geological deposits of coal, acid water is known to result from mining of other types of ores, such as copper, lead, zinc, barite, and manganiferrous ores. In a report submitted to the Committee on Public Works for the House of Representatives in 1962, it was "estimated that 3.5 million tons of acid is discharged into the streams of the United States annually, resulting in major damage to more than 4,000 miles of streams;" this figure includes some acid drainage emanating from mining of ores other than coal. It was also reported that if an estimate of damages included those related to minor creeks and tributaries, the total number of stream miles thereby affected might exceed 16,100 kilometers (10,000 miles). In 1964, the Bureau of

Table 1-6

AQUATIC RESOURCES ADVERSELY AFFECTED BY SURFACE MINING

REGION AND STATE	STREAMS		NATURAL LAKES		RESERVOIRS AND IMPOUNDMENTS	
	MILES	SURFACE ACRES	NUMBER	SURFACE ACRES	NUMBER	SURFACE ACRES
New England	141	2,591	2	100	0	0
Maine	4	5	0	0	0	0
New Hampshire	35	1,500	0	0	0	0
Vermont	32	70	0	0	0	0
Massachusetts	6	600	0	0	0	0
Connecticut	62	415	2	100	0	0
Rhode Island	2	1	0	0	0	0
Middle Atlantic	3,034	9,290	2	100	4	2,020
Pennsylvania	3,000	9,100	0	0	4	2,020
New York	24	100	2	100	0	0
New Jersey	10	90	0	0	0	0
East North Central	1,603	2,806	16	1,560	83	1,520
Wisconsin	Trace	Trace	Trace	Trace	Trace	Trace
Michigan	253	506	16	1,560	32	900
Illinois	60	350	0	0	50	500
Indiana	90	750	0	0	0	0
Ohio	1,200	1,200	0	0	1	120

Adapted from Reference No. 71

Table 1-6 Continued

REGION AND STATE	STREAMS		NATURAL LAKES		RESERVOIRS AND IMPOUNDMENTS	
	MILES	SURFACE ACRES	NUMBER	SURFACE ACRES	NUMBER	SURFACE ACRES
West North Central	1,770	28,014	6	1,600	37	15,325
North Dakota	0	0	0	0	0	0
Minnesota	0	0	6	1,600	0	0
South Dakota	640	3,250	0	0	33	9,275
Nebraska	700	21,600	0	0	0	0
Iowa	0	0	0	0	0	0
Kansas	100	614	0	0	2	50
Missouri	300	2,550	0	0	2	6,000
East South Central	1,050	12,873	0	0	9	16,700
Kentucky	305	7,000	0	0	0	0
Tennessee	390	3,983	0	0	1	100
Mississippi	80	190	0	0	1	300
Alabama	275	1,700	0	0	7	16,300
South Atlantic	1,335	30,640	0	0	20	5,345
West Virginia	755	29,015	0	0	4	4,683
Maryland	115	500	0	0	1	72
Delaware	Trace	Trace	0	0	5	200
Virginia	300	1,015	0	0	0	0
North Carolina	0	0	0	0	0	0
South Carolina	0	0	0	0	0	0
Georgia	165	110	0	0	10	390
Florida	Trace	Trace	0	0	0	0

Adapted From Reference No. 71

Table 1-6 Continued

REGION AND STATE	STREAMS		NATURAL LAKES		RESERVOIRS AND IMPOUNDMENTS	
	MILES	SURFACE ACRES	NUMBER	SURFACE ACRES	NUMBER	SURFACE ACRES
West South Central	1,884	43,273	252	100,200	0	209,873
Oklahoma	20	73	0	0	0	0
Texas	0	0	0	0	0	0
Arkansas	150	700	2	200	0	0
Louisiana	1,714	42,500	250	100,000	0	0
Mountain	1,347	4,489	0	0	14	602
Idaho	134	654	0	0	0	0
Montana	138	234	0	0	0	0
Wyoming	10	200	0	0	0	0
Utah	16	90	0	0	0	0
Colorado	880	1,930	0	0	13	600
Arizona	80	200	0	0	0	0
New Mexico	100	1,150	0	0	1	2
Nevada	41	31	0	0	0	0
Pacific	754	2,594	1	70	1	4
Washington	64	640	0	0	0	0
Oregon	310	620	0	0	0	0
California	320	934	[illegible]	70	1	4
Alaska	60	500	0	0	0	0
Hawaii	0	0	0	0	0	0
TOTAL	12,898	135,970	281	103,610	160	41,516

Adapted From Reference No. 71

Table 1-7

AQUATIC RESOURCES ADVERSELY AFFECTED BY COAL MINING, BY STATE

REGION AND STATE	STREAMS		RESERVOIRS AND IMPOUNDMENTS		PRINCIPAL SPORT FISH AFFECTED
	MILES	SURFACE ACRES	NUMBER	SURFACE ACRES	
Middle Atlantic Pennsylvania	3,000	9,100	4	2,020	Trout
East North Central:					
Illinois	60	350	50	500	Black bass
Ohio	1,200	1,200	1	120	Black bass
Indiana	50	350	0	0	Black bass
Subtotal	1,310	1,900	51	620	
West North Central:					
Kansas	100	614	2	50	Black bass
Missouri	200	1,650	2	6,000	Black bass
Subtotal	300	2,264	4	6,050	
East South Central:					
Kentucky	395	7,000	0	0	Black bass
Alabama	150	15,000	4	15,300	Black bass
Subtotal	545	23,000	4	15,300	Black bass

Adapted from Reference No. 71

Table 1-7 Continued

REGION AND STATE	STREAMS		RESERVOIRS AND IMPOUNDMENTS		PRINCIPAL SPORT FISH AFFECTED
	MILES	SURFACE ACRES	NUMBER	SURFACE ACRES	
South Atlantic					
West Virginia	500	21,000	4	4,683	Trout
Maryland	115	500	1	72	Trout
Subtotal	615	21,500	5	4,755	
Mountain: Colorado	20	80	0	0	Trout
Pacific					
Washington	7	70	0	0	Trout and salmon
Alaska	(a)	(a)	0	0	Trout and salmon
Subtotal	7	70	0	0	
TOTAL	5,797	47,914	68	28,745	

(a) Slight damage indicated.
Adapted From Reference No. 71

Sport Fisheries and Wildlife announced that 97% of acid mine drainage in streams and 93% found in impoundments resulted from coal mining operations. In addition, it has been documented in numerous studies that at least 67% of all coal-related acid mine drainage discharges from underground mine sources. A very high percentage (75-90%) of this drainage emanates from abandoned mine sites.

Reclamation projects to restore offsite areas have been implemented by twenty-five State fish and game departments. Moderate to high successes were reported by 50% of the States. The predominant amount of reclamation is being performed on coal and sand and gravel surface mined areas (See Table 1-8). In a survey conducted by the Bureau of Sport Fisheries and Wildlife, 46 States reported their fishery resources would benefit from surface mined land reclamation (See Table 1-9). Colorado, Oregon, Kentucky, Maryland, Ohio, Pennsylvania, and West Virginia (the last five of which have extensive coal-mined areas) expect the greatest benefits (71). In addition, almost 60% of the States participating in the survey believe water quality control is the first step necessary to improve their fishery resources and that impoundment of water to pool pollutants should initiate their efforts (See Table 1-9). The cost of a National reclamation program to restore surface mined lands, thus alleviating the major pollutional problems of sedimentation and acid mine drainage, is an estimated $2 billion (71).

FORECAST OF FUTURE MINING TRENDS

An adequate supply of minerals and energy is essential toward attaining a progressive economic and social environment in such a society as ours - one which while comprising only 6% of the world's population, nevertheless consumes approximately 33% of the world's energy output and about 25% of the world's current annual mineral production. Even though mineral extraction is one of the most basic industries in the United States, having a direct impact on 40% (and an indirect impact on an additional 35%) of the economy (See Figure 1-4), a planned program is necessary to meet the predicted annual growth demand of 3.4% to 5.5% for the remainder of the century. In formulating and establishing programs and policies requisite to optimum development of our natural resources, appropriate constraints involving the environment and health and safety must be considered. The first step should include determination of future mining trends. This can

Table 1-8

PROJECTS TO RECLAIM
MINED LAND FOR IMPROVEMENT OF FISH, BY STATE

REGION AND STATE	PROJECTS TO BENEFIT FISH	
	REPORTED SUCCESS	COMMODITY MINED
New England:		
Vermont	Moderate	Sand and gravel
Middle Atlantic:		
New York	High	Clay; sand and gravel; stone
Pennsylvania	No benefits	Coal
South Atlantic:		
Florida	High	Phosphate
Georgia	Unknown	Clay
West Virginia	Moderate	Coal; clay; stone; sand and gravel
East South Central:		
Kentucky	No benefits	Coal
Tennessee	Moderate	Stone; phosphate; clay; sand and gravel
East North Central:		
Illinois	High	Coal
Indiana	Unknown	Coal
Ohio	Slight	Coal and clay
West North Central:		
Iowa	Slight	Coal
Kansas	Slight	Coal and clay
Missouri	High	Coal; sand and gravel
Nebraska	Moderate	Sand and gravel
Mountain:		
Idaho	Moderate	Sand and gravel
Montana	High	Copper; stone; gold; sand and gravel
New Mexico	High	Sand and gravel
Pacific:		
California	Moderate	Copper
Oregon	High	Gold

Adapted From Reference No. 71

Table 1-9

EVALUATION OF RECLAMATION
NEEDED FOR IMPROVEMENT OF AQUATIC HABITATS, BY STATE

STATE	MEASURES REQUIRED					IMPROVEMENT SOUGHT IN-				PRINCIPAL SPECIES BENEFITING									
	Grading and drainage	Stream bank stabilization	Channel stabilization	Impoundment to pool pollutants	Other	Water Quality	Spawning habitats	Flow regulation	Other	Trout, salmon	Black basses	Crappies	Bluegills, other sunfishes	Esocids	Percids	Catfish	Shad, herring	Shellfish	Other
Alabama	2			1		1	2				1	3	2			4			
Alaska										1									2
Arizona					1	1			2		2		4			1			
Arkansas				1	2	1	2				2	4	1			3			
California	4	2	1	3		2	1	3		1	2		3						
Colorado	2	3	4	1		1	2		3	1	3					2			
Connecticut	2			1		2	3	1		1	3						2		
Delaware				1			1		2		1	2	3						
Florida					1		1				1	3	2						
Georgia	3	4	2	1		1	2	3			3	4	1			2			
Idaho	3	2	4	1		1	2	3		1	2	5	3		4				
Illinois	2				1	1	3	2		5	1	4	2			3			
Indiana	3	4	2	1		1	2		3		1	3	2			4			
Iowa	2				1	1	2	3			1		2			3			
Kansas	1					1			2		1	4	3		5	2			
Kentucky	1	4		2	3	1	2	3			1		2			3			
Louisiana	2			1		1	2				1	2	3			4		5	6
Maine	2			1			1			1									
Maryland	1				2	1	2			1	2		3			4			
Massachusetts				1		1					1		3			2			

Adapted from Reference No. 71

Table 1-9 Continued

STATE	MEASURES REQUIRED					IMPROVEMENT SOUGHT IN-				PRINCIPAL SPECIES BENEFITING									
	Grading and drainage	Stream bank stabilization	Channel stabilization	Impoundment to pool pollutants	Other	Water Quality	Spawning habitats	Flow regulation	Other	Trout, salmon	Black basses	Crappies	Bluegills, other sunfishes	Esocids	Percids	Catfish	Shad, herring	Shellfish	Other
Tennessee	2			1		2	1				1	3	2					4	5
Utah				1		1				1									
Vermont				1			2		1	1	2								
Virginia	2	3	4	1		1	2			4	1	2	3	5		6	7		
Washington	1			2		2	1			1									
West Virginia	1				2	1				1	2	3	4	6	7	5			
Wisconsin										1	3	4	2						
Wyoming				1		1													
Number of States emphasizing item	27 27	14	14	32	12	38	32	14	11	25	35	17	28	6	6	23	4	3	5

Adapted From Reference No. 71

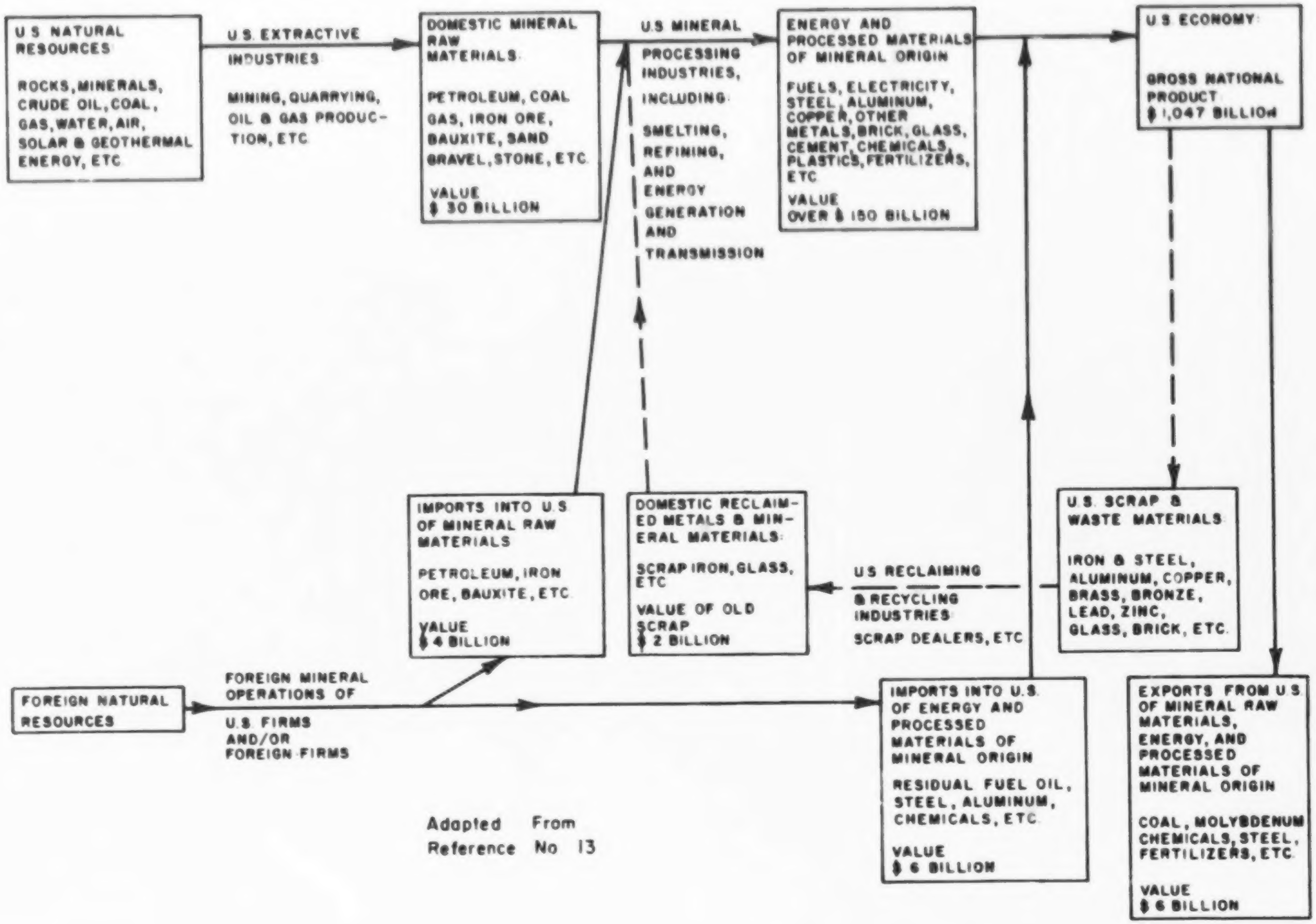
(Rank of importance indicated by 1,2,3, etc., no evaluations from Hawaii, North Carolina, South Carolina, and Texas)

[1] State benefited by creation of many small lakes

Table 1-9 Continued

STATE	MEASURES REQUIRED					IMPROVEMENT SOUGHT IN-				PRINCIPAL SPECIES BENEFITING									
	Grading and drainage	Stream bank stabilization	Channel stabilization	Impoundment to pool pollutants	Other	Water Quality	Spawning habitats	Flow regulation	Other	Trout, salmon	Black basses	Crappies	Bluegills, other sunfishes	Esocids	Percids	Catfish	Shad, herring	Shellfish	Other
Michigan	2			1		1	2			2	1			3	4				
Minnesota					1	3	1		2		2		1	3					
Mississippi				1		2	3	1			3		2			1			
Missouri	3		2	1		1		2			1		3			2			
Montana	2	3	4	1		1	2		3	1									
Nebraska	2			1					1		2	4	3			1			
Nevada		2	3	1		1				1									
New Hampshire					1	2	1			6	1			2	4	3	5		
New Jersey			2	1		1	2	3			1	2	3		4				
New Mexico	3	4	2	1		1	2		3	1						2			
New York	3	2	1	4		2	1			1	2							3	4
North Dakota[1]																			
Ohio	1				2	1	3	2			1	4	3			2			
Oklahoma				1		1					1		3			2			
Oregon		2	1	3		2	1	3		1									
Pennsylvania	2	3			1	1	4	3	2	1	2		4				5		
Rhode Island				1		1				1									
South Dakota	4	2	3	1		1	3	2		1	2					3			

Adapted from Reference No. 71


U.S. NATURAL RESOURCES:
ROCKS, MINERALS, CRUDE OIL, COAL, GAS, WATER, AIR, SOLAR & GEOTHERMAL ENERGY, ETC.
U.S. EXTRACTIVE INDUSTRIES:
MINING, QUARRYING, OIL & GAS PRODUCTION, ETC.
DOMESTIC MINERAL RAW MATERIALS:
PETROLEUM, COAL GAS, IRON ORE, BAUXITE, SAND GRAVEL, STONE, ETC.
VALUE $ 30 BILLION
U.S. MINERAL PROCESSING INDUSTRIES, INCLUDING:
SMELTING, REFINING, AND ENERGY GENERATION AND TRANSMISSION
ENERGY AND PROCESSED MATERIALS OF MINERAL ORIGIN
FUELS, ELECTRICITY, STEEL, ALUMINUM, COPPER, OTHER METALS, BRICK, GLASS, CEMENT, CHEMICALS, PLASTICS, FERTILIZERS, ETC
VALUE OVER $ 150 BILLION
U.S. ECONOMY:
GROSS NATIONAL PRODUCT $ 1,047 BILLION
IMPORTS INTO U.S. OF MINERAL RAW MATERIALS
PETROLEUM, IRON ORE, BAUXITE, ETC.
VALUE $ 4 BILLION
DOMESTIC RECLAIMED METALS & MINERAL MATERIALS:
SCRAP IRON, GLASS, ETC
VALUE OF OLD SCRAP $ 2 BILLION
U.S. RECLAIMING & RECYCLING INDUSTRIES:
SCRAP DEALERS, ETC
U.S. SCRAP & WASTE MATERIALS:
IRON & STEEL, ALUMINUM, COPPER, BRASS, BRONZE, LEAD, ZINC, GLASS, BRICK, ETC.
FOREIGN NATURAL RESOURCES
FOREIGN MINERAL OPERATIONS OF U.S. FIRMS AND/OR FOREIGN FIRMS
IMPORTS INTO U.S. OF ENERGY AND PROCESSED MATERIALS OF MINERAL ORIGIN
RESIDUAL FUEL OIL, STEEL, ALUMINUM, CHEMICALS, ETC.
VALUE $ 6 BILLION
EXPORTS FROM U.S. OF MINERAL RAW MATERIALS, ENERGY, AND PROCESSED MATERIALS OF MINERAL ORIGIN
COAL, MOLYBDENUM CHEMICALS, STEEL, FERTILIZERS, ETC.
VALUE $ 6 BILLION

Adapted From Reference No 13

Figure I-4. The role of minerals in the United States economy

(ESTIMATED VALUE FOR 1971)

be attained through a quantitative forecast evaluating demand, production, and reserve-resource statistics. A "resource" is a material known to exist in the earth's crust or judged by geologic inference and extrapolation as likely to exist, while a "reserve" is that portion of the actual identified material which can be economically and legally extracted at the time of determination. In the First Annual Report of the Secretary of the Interior Under the Mining and Minerals Policy Act of 1970 (Tables 1-10 and 1-11), this was precisely accomplished (also See Appendix, Figures A-1 thru A-21), for resource locations. Reserves, production, and demand are interrelated and must be critically examined together for a complete understanding of the resource problem. One method useful in providing a clear and concise measure of known and future available inventories is compilation of reserve indices (expressed in years) (26):

$$\frac{\text{reserves}}{\text{annual production}} = \text{reserve-production index}$$

$$\frac{\text{reserves}}{\text{annual consumption}} = \text{reserve-consumption index}$$

However, consideration must be given to possible changes in the index due to such variable factors as demand, economics, technology and new discoveries. These indices can be valuable for relative comparisons of which commodities will require more intensive research and exploration, as well as possible changes in traditional production, demand, and reserve forecasting.

Mineral reserves are not finite quantities, but rather are continually changing entities. They may be altered indirectly by reduced production, a decrease in commodity price, an increase in extraction and/or processing costs, increased use, or availability of substitute materials. They may be directly increased by exploratory discoveries and progressive technology developments. However, the influence of these factors upon the reserve supply rests upon a basic economic relationship - that of the selling price of the mineral commodity to its respective production cost. The following table is an example of the varying reserve-resource relationship to changing costs:

Domestic Uranium Resources, Jan. 1, 1974
(tons of U_3O_8, cumulative)

Cost of production* ($ per lb)	Reasonably assured (proved reserves)	Estimated additional (resources)	Total
$ 8 (or less)......	275,000	450,000	125,000
10 (or less)......	430,000**	700,000	1,130,000
15 (or less)......	525,000**	1,000,000	1,525,000
30 (or less)......	700,000**	1,700,000	2,400,000

*Based on the forward cost of production, not including amortization of past investments, interest, or income taxes; no provision is made for return on investments, does not necessarily represent the market price.

** Includes 90,000 tons of potentially recoverable U_3O_8 as a by-product of phosphate and copper mining at a cost of $10 per lb or less.

Source: Atomic Energy Commission

Therefore, not only reserve statistics, but also resource statistics, are necessary in order to properly assess the total resources of a specific mineral commodity.

Table 1-12 allows the assessment of future deficits of the specific mineral commodities relative to one another. This table appropriately reflects relative magnitude of each deficit problem by demonstrating resultant monetary impact of each commodity. Demand projections were based upon integration of several factors: historical growth and use pattern for each commodity in relation to gross national product, population, and industrial production (their respective growth rates); and the best technical information on probable new uses, substitutions, and availability of resources (73). Extrapolation of future domestic production for each mineral commodity by straight line projection of the past 20-year trend was utilized in compiling the production projections (73). However, such considerations are accurate only in so far as historic trends are consistent and predictable, an assumption which may very well be false.

Table 1-10

COMPARISON OF PRIMARY DEMAND
AND PRODUCTION FOR 1970, 1985 AND 2000, BY COMMODITY[1]

	COMMODITY	1970		1985		2000	
		DEMAND	PRODUCTION	DEMAND	PRODUCTION*	DEMAND	PRODUCTION*
METALS	Aluminum	3,951	583	11,500	490	26,400	503
	Copper	1,572	1,720	2,900	1,910	5,400	2,380
	Gold[2]	6,147	1,743	9,200	1,270	14,300	1,000
	Iron	84,000	59,000	113,000	51,000	153,000	50,000
	Lead	829	572	1,090	420	1,430	470
	Magnesium, metallic	96	112	235	115	580	142
	Manganese	1,327	66	1,770	0	2,360	0
	Mercury[3]	54	27	66	37	80	44
	Molybdenum	24,552	55,676	48,250	70,000	94,000	92,000
	Silver[2]	73,100	45,000	124,000	39,000	210,000	40,000
	Titanium, metal	24	0	65	0	168	0
	Tungsten	8,100	4,053	17,100	2,250	37,000	1,130
	Uranium	8	11	51	21	62	28
	Zinc	1,302	534	1,820	500	3,000	486
NONMETALS	Barium	787	478	1,000	460	1,380	419
	Boron	88	175	163	255	303	345
	Clays	53,000	55,000	96,000	70,000	174,000	82,000
	Diatomite	444	598	942	963	2,000	1,250
	Feldspar	647	728	1,422	942	2,800	1,142
	Gypsum	14,334	9,436	22,400	10,900	35,000	11,700
	Magnesium, nonmetallic	1,057	1,029	1,510	1,410	2,160	1,670
	Mica, scrap	119	119	231	180	448	227
	Mica, sheet	3,257	0	985	0	300	0
	Phosphorous	3,630	5,236	6,590	8,500	12,000	11,700
	Potassium	3,908	2,265	6,850	3,660	12,000	4,640
	Sand & Gravel	944,000	944,000	1,740,000	1,450,000	3,200,000	1,900,000
	Stone, crushed	648,000	648,000	1,280,000	1,130,000	2,520,000	1,560,000
	Stone, dimension	1,740	1,565	2,580	2,030	3,820	1,880
	Sulfur	10,228	10,695	18,480	13,210	33,600	16,240
FUELS	Coal, anthracite	8,248	9,729	5,000	0	2,300	0
	Coal, bituminous and lignite	517,000	603,000	845,000	612,000	1,000,000	690,000
	Peat	800	517	1,405	1,070	2,200	1,450
	Shale, Oil	0	0	-	-	-	-

Adapted From Reference No. 73

*Projections based on the past 20-year trend, 1951-1970. However, the effects of economic, technological, environmental, political, and social factors may alter the supply-demand trends of a specific mineral commodity, and may also affect other commodities where interrelationships are involved. In such cases significant departures from the 20-year trends could result.

(1) - All demand and production figures expressed in thousand tons except where noted.
(2) - Thousand Troy Ounces.
(3) - Thousand Flasks.

Table 1-11

ESTIMATED RESERVES
AND RESOURCES, BY COMMODITY

	COMMODITY	RESERVE[1]	RESOURCE[2]
METALS	Aluminum	50,400	Small
	Copper	81,000	Large
	Gold[3]	52,000	Moderate
	Iron Ore	11,200,000	Large
	Lead	35,000	Large
	Manganese	0	Large
	Mercury[4]	300	Moderate
	Molybdenum	[illegible],150	Large
	Silver[3]	1,300,000	Moderate
	Titanium	100,500	Large
	Tungsten	90	Moderate
	Zinc	30,000	Large
NONMETALS	Barite	[illegible],000	Large
	Borates	95,000	Not Known
	Brucite	9,000	Not Known
	Clay	Large	Large
	Diatomite	300,000	Large
	Feldspar	500,000	Large
	Gypsum	350,000	Large
	Magnesite	65,000	Not Known
	Mica	Large	Large
	Phosphate Rock	7,850,000	Large
	Potash	460,000	Large
	Salt[5]	60,000	Large
	Sand & Gravel	Large	Large
	Stone	Large	Large
	Sulfur	84,000	Large
Fossil Fuels	Coal[5]	1,770	Large
	Peat	14,000,000	Large

Adapted From Reference No. 73

[1] [illegible] expressed in Thousand Short Tons except where [illegible]

[illegible]

[illegible]

[illegible]

[illegible]

Table [illegible]

[illegible]

[illegible]

While major uncertainties exist and are inherent in any attempt to predict future demand for minerals, this situation can be accentuated by lack of specialized regional assessment of each commodity. This is required since demand-supply statistics are limited; they entail no consideration as to the economic feasibility of providing high demand regions with commodities from a distant supply source. Because of high transportation costs, some minerals (especially large bulk, low cost materials like sand, gravel and stone) simply cannot economically be transported long distances. Since such supply materials are not economically available, they may be more appropriately classified as resource, rather than reserve, material.

In the socio-political field there are such critical forces as public policy, population growth, and foreign nationalization impact at work, significantly altering mine development and expansion. Public policy can vary according to public opinion and can radically alter mineral exploration and development through availability of public lands, zoning laws dealing with mineral commodity extraction, public funding for fundamental research expansion pertaining to mineral exploration, extraction, beneficiation, transportation and other auxiliary-related systems, and enactment and judicial interpretation of laws concerning mineral and lands leasing, mineral disposal, prediscovery protection, mined land reclamation and taxation. Public policy can alter or create demands for mineral commodities through such actions as government stockpiling or disposal of materials and initiating specialized government programs such as aerospace adventures, national defense, or energy development. Population growth can create a substantial increase in demand for goods, especially if there is a concurrent increase in per capita consumption. With concern for overpopulation and its consequential "zero population growth" philosophy, a dramatic change in demand could result. A substantial affect upon our mineral supply and prices can be effected through foreign expropriation or forced modifications of foreign agreements.

In the environmental field there are various constraints on industry to protect the environment, however, there is always the impending possibility of a modification of these requirements. Such constraints include air pollution controls, water pollution controls, land disposal controls, mined land reclamation, and the not-so-publicized but critical restraints upon exploratory adventures.

In the economic field, price increasing is the most important factor and one which may have far-reaching effects; consumers of raw materials will turn toward cheaper foreign sources (unless interdicted by import controls) and will thus have an adverse affect upon our balance of payments. When this happens, investment and employment potential in domestic mineral extraction and processing can be severely inhibited.

In the technological area, future mineral trends may be acutely affected by technological advances in synthesizing or otherwise producing new or substitute materials, recycling resources, solving environmental problems, and innovating exploration procedures, mineral extraction techniques, and beneficiating processes.

These are some of the factors which significantly influence future trends. However, it should be realized the consequence of all previously-mentioned considerations is a lack of certainty as to the future. This can produce a lack of investment interest with a resulting negative (reverse) effect.

Forecast for Surface vs. Underground Mining

Surface mining accounts for approximately 85% of metallic ore production, [illegible] of nonmetallic ore production, and 49% of fossil fuel production in the United States. These percentages are anticipated to increase in the future (See Tables 1-13 and 1-14). Although underground mining has been relatively stable, total material mined has grown at an annual rate of 3.2% from 1960 to 1972 (78).

This discrepancy between the two techniques has emerged due to the distinct advantages, delineated in the Mining Methods section, associated with surface mining: higher mineral recovery (90% average recovery for surface mine vs. 50% average recovery for underground mines), much greater production per man day, more economical operation in terms of capital costs and cost per production unit, better health and safety conditions (elimination of underground fire, explosion, and cave-in hazards, as well as reduction in noise and dust pollution problems), and more flexibility of operation. The phenomenal advance in surface mining technology which has taken place during the past forty years has permitted economic feasibility of

Table 1-8

CRUDE ORE AND TOTAL MATERIAL
HANDLED AT SURFACE AND UNDERGROUND MINES¹, 1972, BY COMMODITY

COMMODITY	CRUDE ORE		TOTAL MATERIAL	
	SURFACE	UNDERGROUND	SURFACE	UNDERGROUND
Bauxite	[illegible]	[illegible]	[illegible]	[illegible]
Copper	[illegible]	[illegible]	[illegible]	[illegible]
Iron				
Crude	[illegible]	[illegible]	[illegible]	[illegible]
Usable	[illegible]	[illegible]	[illegible]	[illegible]
Lead-Zinc	[illegible]	[illegible]	[illegible]	[illegible]
Gold	[illegible]	[illegible]	[illegible]	[illegible]
Mercury	[illegible]	[illegible]	[illegible]	[illegible]
Molybdenum	[illegible]	[illegible]	[illegible]	[illegible]
Silver	[illegible]	[illegible]	[illegible]	[illegible]
Titanium	[illegible]	[illegible]	[illegible]	[illegible]
Tungsten	[illegible]	[illegible]	[illegible]	[illegible]
Uranium	[illegible]	[illegible]	[illegible]	[illegible]
Zinc	[illegible]	[illegible]	[illegible]	[illegible]
Other	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]
Barite	[illegible]	[illegible]	[illegible]	[illegible]
Cement	[illegible]	[illegible]	[illegible]	[illegible]
Clays	[illegible]	[illegible]	[illegible]	[illegible]
Diatomite	[illegible]	[illegible]	[illegible]	[illegible]
Feldspar	[illegible]	[illegible]	[illegible]	[illegible]
Gypsum	[illegible]	[illegible]	[illegible]	[illegible]
Magnesite	[illegible]	[illegible]	[illegible]	[illegible]
Mica (scrap)	[illegible]	[illegible]	[illegible]	[illegible]
Mica (sheet)	[illegible]	[illegible]	[illegible]	[illegible]
Phosphate Rock	[illegible]	[illegible]	[illegible]	[illegible]
Potassium Salts	[illegible]	[illegible]	[illegible]	[illegible]
Salt	[illegible]	[illegible]	[illegible]	[illegible]
Sand & Gravel	[illegible]	[illegible]	[illegible]	[illegible]
Stone				
Crushed	[illegible]	[illegible]	[illegible]	[illegible]
Dimension	[illegible]	[illegible]	[illegible]	[illegible]
Other	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]
Coal	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	[illegible]	[illegible]	[illegible]	[illegible]

Adapted From Reference No. 39.

W = Withheld to avoid disclosing individual company confidential data; included with "surface".

NA = Not Available.

¹ Value expressed as percentage of total.

Table 1-14

CRUDE ORE HANDLED
AT SURFACE AND UNDERGROUND MINES,[1] 1975 BY STATE

STATE	METALS AND NONMETALS		COAL	
	SURFACE	UNDERGROUND	SURFACE	UNDERGROUND
[illegible]	98	2	14	86
Alaska	100	–	100	0
Arizona	90	10	100	0
Arkansas	98	[illegible]	98	2
California	99	1	–	–
Colorado	36	64	44	56
Connecticut	100	–	–	–
Delaware	100	–	–	–
Florida	100	–	–	–
Georgia	99	–	–	–
Hawaii	100	–	–	–
Idaho	91	9	–	–
Illinois	97	[illegible]	51	49
Indiana	97	3	94	6
Iowa	96	4	59	41
Kansas	89	11	100	0
Kentucky	86	14	59	41
Louisiana	89	11	–	–
Maine	99	1	–	–
Maryland	100	–	91	9
Massachusetts	100	–	–	–
Michigan	92	8	–	–
Minnesota	100	–	–	–
Mississippi	100	–	–	–
Missouri	94	6	100	0
Montana	98	2	99	1
Nebraska	96	4	–	–
Nevada	100	–	–	–
New Hampshire	100	–	–	–
New Jersey	99	1	–	–
North Carolina	100	–	–	–
North Dakota	100	–	100	0
Ohio	94	6	68	32
Oklahoma	97	3	87	13
Oregon	100	–	–	–
Pennsylvania	98	[illegible]	35	65
Rhode Island	100	–	–	–
South Carolina	100	–	–	–
South Dakota	92	8	–	–
Tennessee	86	14	48	52
Texas	100	–	100	0
Utah	99	1	1	99
Vermont	99	1	–	–
Virginia	97	3	41	59
Washington	99	1	99	1
West Virginia	90	10	18	82
Wisconsin	99	1	–	–
Wyoming	70	30	96	4
TOTAL	94	6	46	54

Adapted from Reference No. 39, 79.

[1] Values expressed as percentage of Total.

extracting lower grade and quality ores. At a time when mining of higher grade ores could not fulfill the increasing needs of our industrialized society, technological advances increased productivity to meet these needs by opening a large reserve of low grade ores located near the surface. Primary improvements were initiation of AN/FO (Ammonium Nitrate - Fuel Oil) explosives, rotary drilling, various auxiliary labor-saving devices, an increase in capacities of surface excavators and trucks, and in general scale of the entire operation, a shift from rail to truck haulage, and distinctive modifications in mineral beneficiation. The technological advances in the surface mine industry seem to have reached a plateau, and at least a temporary restraint in size of equipment is occurring. Due to lower operating efficiencies of larger excavating equipment, the future trend should include a concerted effort to improve current designs.

In contrast, underground mining technology is now intensively being employed to improve productivity through research related to modified loading machines, versatile shuttle cars, automated roof support bolters, longwall and shortwall mining techniques, and various other remote and semi-remote controls. All of these, in addition to improving productivity, should contribute to a marked reduction in problems pertaining to the health and safety of the miner. Techniques such as longwall mining could approach or equal the 90 percent mineral recovery level of surface mine operations (8). Technological advances in other areas (such as rock boring machines for reclamation projects and rapid excavation techniques for military projects) may be applicable to underground mineral extraction. Such advances could very well change the productivity decline of the past six years in underground mining (especially in coal mining, since at the present time about 40 percent of underground coal mined is by conventional methods, while that being mined continuously is producing less than 11 percent of its theoretical capability (85).

Other factors to be considered in forecasting the trend for future underground mining vs. surface mining are the favorable environmental and aesthetic advantages of underground mining, the subjectivity of surface operations to vagaries of weather conditions, economic and physical limitations (stripping ratios) of surface mining, and most importantly the physical character of mineable reserves. Because of peculiarity of their physical environment, such important minerals as lead, zinc, lode gold, potash, and salt are likely to continue to be mined (at least a preponderance of each) by underground methods.

However, surface mining of copper, stone, phosphate, gypsum, and other valuable minerals which have thick-bedded or massive deposits are likely to be successfully challenged in the future by underground mining methods. There are indications that even coal and iron ore deposits may be competitively mined underground with the advancement of improved underground technology (50).

FORECAST OF MINERAL COMMODITIES

By the year 2000, domestic demand for primary mineral commodities is anticipated to be about 10 billion metric tons (11 billion tons) valued at $117 billion. If we are to meet our increasing mineral needs while simultaneously protecting our environment, the complex problems to be encountered and solved must be anticipated. Since no forecasting generalization is applicable to all mineral commodities mined in the United States, attention must be directed to mineral groups in order to properly assess our overall mineral position and associated problems which lie ahead.

Metals

During the period of 1950 - 1971, domestic demand for metals tripled, accounting for 36% of the total mineral demand by 1971. This increase in trend is likely to continue with a projected metallic demand accounting for 43% of total mineral demand by the year 2000 (73). Domestically-produced metal ores were valued at over $3 billion in 1971. The major minerals to be used as an index in this category are iron ore, aluminum, copper, lead, zinc, and uranium.

Iron

Iron ore, the most important metal commodity, is expected to increase in demand at a 2% rate to the year 2000. Although production of iron ore as based upon a 20-year trend is expected to decline (Table 1-10), anticipated technological advances should, result in increased production.

Aluminum

Primary demand for aluminum is expected to increase at a 6% annual rate. However the projected production as extrapolated from its 20-year trend is calculated to decrease (Table 1-10). A more realistic prediction is for a slight increase in primary aluminum production.

Copper

Copper's projected primary demand is an annual 4% rise to the year 2000 with a concurrent production increase (Table 1-10).

Lead

The projection for primary demand of lead is an annual 2% increase. As extrapolated from past trends, primary production should decrease; however, due to high future demands (Table 1-10) and a large domestic reserve base, lead production is expected to moderately increase.

Zinc

An annual demand increase at a rate of 3% to the year 2000 is projected for zinc, yet a decrease in zinc production, as based upon past trends, is anticipated (Table 1-10). Due to foreign competition, obsolete zinc smelters, substitution of other minerals, possible new reserves, and improved efficiency in mining and metallurgical processes, a more realistic prediction of future zinc production cannot be made.

Uranium

The past trend for uranium has been erratic; a large growth in the 1950's occurred due to a stimulated procurement program by the Atomic Energy Commission and was subsequently followed by a decrease due to abandonment of the program. The forecast for future demand and production of uranium is dependent upon many contingencies, including successful development and use of fast-breeder reactors, public concern over environmental problems and risk of future accidents or related hazards, and developments by competing energy systems. However, at this time the projected 20 year growth for uranium mining and processing capacity is 800%. The current energy crisis and "Project Independence" have dictated this tremendous expansion program.

Nonmetallic Minerals

Nonmetallic mineral demand accounted for 8% in 1971, and is projected to rise to 11% by the year 2000. Domestically-produced nonmetallics are estimated to have valued $6 billion in 1971. The major nonmetals to serve as index for this category are stone, sand and gravel, clay, salt, phosphate, and sulfur.

Stone

Stone, the largest tonnage item, is expected to increase in demand at an annual rate of 4% for the next few years. Its production is also expected to increase in the future (Table 1-10), but this is mainly dependent upon favorable conditions in the construction industry.

Sand and Gravel

Sand and gravel markets are growing at an annual rate of 4% and production is expected (from past trends - Table 1-10) to expand in the future. Its production is also based upon demands of the presently unstable construction industry whose consumption accounts for 96% of total sand and gravel demand.

Clay

Clay demand is expected to increase at a 3.5% annual compound rate and concurrent expansion in production is expected to result (Table 1-10).

Salt

An annual rate increase of 4% per year in salt demand will comprise its future long-term trend with a concurrent production increase due to expected development of new mines and innovation of older ones.

Phosphate Rock

A very stable and favorable situation and forecast exists for phosphate rock. Its demand is expected to increase at an annual rate of 4% for the next few years and slight production expansion will easily fulfill these needs (Table 1-10). Due to its importance in production of fertilizer (74% of the total phosphate production is consumed by the fertilizer industry), phosphate rock production should steadily increase in the future. However, anticipated higher prices and foreign competition threatens future export markets.

Sulfur

Sulfur domestic demand is forecast to increase at a 4% annual compound rate with a predicted decrease in production (as based upon past trends - Table 1-10). Nevertheless, not only is production realistically expected to increase due to high demand, but also a possible situation of overproduction could result from environmental-related sources, such as sulfur removal from stack gases and from gasification and liquefaction of coal.

Energy

During the period of 1950-1971, domestic demand for energy doubled, accounting for 55% of total mineral demand in 1971, and an annual growth rate of 4% has been predicted. In order to meet these increasing needs, emphasis must necessarily be placed upon coal mining.

Coal

Prior to the energy crisis domestic coal demand was forecast to increase 4% annually (Table 1-10). However, due to the energy crisis and "Project Independence", anticipated demand and production rate will require a total increase of approximately 100% over present day figures. In order to fulfill energy needs by 1985, the National Academy of Engineering, in a study published in May, 1974, promulgated the following requirements for the coal industry:

> ". . . Develop 140 new 2 million tons per year Eastern Underground mines.
>
> . . . Develop 30 new 2 million tons per year Eastern Surface mines.
>
> . . . Develop 100 new 5 million tons per year Western Surface mines.
>
> . . . Recruit and train 80,000 new Eastern coal miners.
>
> . . . Recruit and train 45,000 new Western coal miners.
>
> . . . Manufacture 140 new 100 cubic yard shovels and draglines.
>
> . . . Manufacture 2,400 continuous mining machines."

For the coal industry, such a dramatic challenge can only be met by overcoming several serious economic, environmental, and technological problems. However, an abundant resource base exists to fulfill these proposed needs if the abovementioned problems can be overcome. Less than 5% of total resources are recoverable as based upon current technology, economics, and environmental regulations. Anthracite coal's future is not as promising. Its demand is forecast to decline at an annual rate of 4% - 5% with a concurrent decline in production. Primarily, this steady decline is the consequence of its unfavorable cost relationship to competing energy sources - its unit cost is the highest of all fossil fuels. Basic problems involved are antiquated mining technology, serious environmental considerations, and a lack of skilled manpower. Although the past 20-year trend in production can be extrapolated to zero production by 1985 (Table 1-10), anthracite mining should be a viable industry in the future due to technological advances, training programs, and demand (caused by the energy crisis and demand in the East for low sulfur coal to meet environmental regulations).

Oil Shale

Oil shale, a mineral from which an oil similar to petroleum can be extracted, may soon become a prominent mineral in our energy group of resources. Although not yet commercially tapped, oil shale deposits are expected to be producing oil in the near future. However, research and development projects must first overcome technological problems pertaining to in situ retorting, environmental considerations, and legal problems dealing with land use and mining claims. Since large volumes of water are required in the retorting and processing phase of oil shale, availability of water in the semi-arid oil shale regions (Colorado, Utah, and Wyoming) may become a limiting factor to production. Therefore, production by the year 2000 may be as high as 2 billion barrels per year or as low as zero.

CHAPTER 2

ENVIRONMENTAL IMPACTS OF MINING

ENVIRONMENTAL IMPACTS OF MINING

Mining activities, extraction through processing, obviously disturb the environment. However, current legislative controls and guidelines have helped to minimize operational and post-operational effects from mining procedures. This has not always been the case, evidenced by numbers of abandoned mine sites throughout the country. Although current legislation and restrictions on active mines reduce potential environmental disturbances, adverse impacts from abandoned mines can, in some instances, off-set advantages gained by active mine regulation. Environmental impacts from vacated mines generally emanate from one or more of the following categories:

- Altered Landscapes - topography changes, landslide potentials, vegetation changes and erosion.
- Water Quality Degradation - sedimentation of streams; acid, alkaline, or saline drainage; and heavy metal concentration drainage and radioactivity.
- Air Pollution - dust production, eye irritants, burning refuse bank contributions (SO_2, CO, etc.).

One of the most obvious impacts of orphan mined lands is that of landscape alteration. This terrestrial disruption consists of abandoned overburden or spoil piles, refuse banks, open strip cuts, open pits and quarries, haul and access roads, tailings areas (piles, ponds, dams, sumps, dumps), underground mine openings, and mine structures (processing facilities, storage buildings, equipment). The extent of landscape alteration is very much dependent upon the mining methodology employed at the site, as well as type of mineral extracted. Minerals or ores requiring extensive preparation and classification, such as copper and iron with their associated tailings areas, disturb a greater land area than other minerals, such as granite or limestone, which affect very little land in addition to the mine.

IMPACTS OF SPECIFIC MINERAL INDUSTRIES

Mine drainage and water pollution problems associated with major minerals are indicated on the following page:

Bauxite

Red mud residues result when alumina is extracted from bauxite ore, and consist largely of complex sodium aluminum silicates, and iron oxides. Although these insoluble materials do not contribute to chemical pollution, they can become significant sources of sediment emissions from eroded tailings basins.

Copper

Drainage characteristics associated with copper mining include quantities of acid, ferrous iron, copper, manganese, magnesium, sulfates, lead, cadmium, nickel, zinc, mercury, and arsenic.

Gold

Being extracted as a by-product from other metal mining operations, drainage problems are similar to other metals (copper). However, serious sedimentation problems do occur from abandoned tailings areas resulting from dredging.

Iron Ore

Oxidation of iron sulfides produces acid discharges which in turn cause dissolution of numerous metal ions, similar to those discussed for copper.

Metal mines, in general, have similar types of mine drainage discharges. Low pH and abnormal concentrations of metallic ions are common, along with occasional traces of other elements (Boron, Molybdenum, Barium, etc.).

Non-metallic abandoned mine sites do not have the major chemical mine drainage problems associated with metal mines, i.e. acidic highly mineralized waters. They do, however, contribute significantly to stream sedimentation disturbances from abandoned tailings ponds, settling basins, spoil banks and waste dumps.

Fossil fuel production, particularly from anthracite, bituminous, and lignite coal mining, has gained the reputation of producing severe acid mine drainage problems. Oxidation of pyritic materials causes acid and ferrous iron production. Further oxidation of ferrous iron results in ferric hydroxide which coats stream bottoms with a yellowish-orange precipitate, commonly referred to as "yellow-boy." The impacts of mine drainage from abandoned coal mines are extensively outlined in numerous reports such as, "Stream Pollution by Coal Mine Drainage in Appalachia," by the Federal Water Pollution Control Administration, U. S. Department of the Interior, and the series of reports by the Appalachian Regional Commission on Acid Mine Drainage in Appalachia.

IMPACTS OF SPECIFIC MINING TECHNIQUES

Open Pit

The most commonly utilized surface mining method, this results in a large "open pit," extending well below the original ground surface topography. Abandoned open pits vary over a wide range of configurations. The mineral or commodity extracted greatly influences final dimensions of an open pit. Large chasms created by copper and iron open pit mines allow little potential for reclamation or land reuse. Excessively deep, and consisting of numerous operating benches and haulage roads, these pits drastically and permanently alter terrestrial surroundings.

Other open pits, those associated with non-metallic minerals such as limestone, marble and granite, are not usually as large as those created by metal mining. Such operations when abandoned, often form water impoundments due to interruption of subsurface water flows. Although water quality is not usually affected by these impoundments, mere existence of deep, water filled, unprotected pits creates an attraction for youthful exploration - a hazardous situation.

Abandoned open pits invariably leave some sort of highwall or unprotected slope conditions. Whether it consists of three faces, characteristic of mountainside excavation, or is totally enclosed, an inactive or abandoned open pit has the potential for rock spalling, sloughing, and sliding, creating a potentially dangerous safety and pollutional situation. Backfilling open pits for reclamation and highwall elimination has not been practiced due to prohibitive costs involved, and also due to the great volume of mineral extracted and consumed as compared to material available for reclamation work.

A major characteristic of most all open pit mines is the large area required for overburden, tailings, and processing waste disposal. In some instances, these acreages are in excess of that affected by the actual pit. The landscape impact of tailings and waste disposal areas is very significant. These disposed non-salable commodities inhibit natural vegetative growth due to lack of plant nutrients, exposed toxic salts and inert materials, and presence of dark rock capable of absorbing enough heat to be fatal to plant life. Lack of plant growth limits or eliminates wildlife habitats, causes severe erosion problems, and permits infiltration of surface water through refuse piles, often leaching toxic chemicals into nearby streams. Erosion results from surface streams flowing across and along the margins of tailings areas, and from seasonal surface runoff. After periods of extensive erosional losses, landslides and slumping of waste piles can cause sudden toxic sediment loads to discharge into receiving streams.

Area Surface

In contrast to long-lived open pit mines (50 years or more in most instances), area mining activities are relatively short-lived. That is, mining time (weeks, months) is very short on a per acre disturbed basis. Fifty years of area surface mining will disturb a much greater acreage than fifty years of open pit mining, particularly when area mining coal.

Abandoning area mines prior to any reclamation efforts leaves the disturbed acreage in a series of sharp ridges and valleys, similar to a "washboard" effect. Past area mining activities, especially in the coal bearing portions of the Midwest, were conducted with little or no regard to spoil segregation or special materials handling - the result, an inverted soil profile. Deserted spoil ridges can contain acid forming or toxic materials which prohibit plant growth, thus providing an avenue for wind and water erosion. It is not uncommon for abandoned area mine sites to contain numerous small pockets of water between the ridges. Final cuts or last operating pits usually fill with water to form impoundments, bounded on one side by a spoil bank and on the other by a highwall.

Contour Surface

The most significant landscape impacts resulting from abandoned or inactive mines were created by contour mining methods. Numerous studies and investigations have been conducted on the impacts and effects of deserted contour strip mines, particularly those operated for coal production in the Appalachian Region of this country. Briefly, terrestrial disturbances consist of exposed highwalls along the previous contour outcrop of the coal seam, a nearly level bench at the base of that highwall, and a barren mound of displaced overburden material at the end of the bench which was indiscriminantly cast on the downslope. The impacts of these past reckless mining practices are far-reaching. Extensive erosion and landslides commonly result from poor outslope stability, along with very significant quantities of acid mine drainage due to oxidation of pyritic materials. Sedimentation and iron deposits in nearby waterways destroy aquatic biota and discolor stream beds. There are many variations of contour mine configurations, including spoil ridges from successive cuts into the hillside, several "bands" of disturbances from stripping multiple coal outcrops, and effects of augering the exposed highwall coal seams.

Auger

The augering process, which consists of "drilling" the coal seam from the highwall with large "bits" (up to 2.1 meters in diameter), has also contributed to landscape alterations. Exposed auger holes can be direct sources of mine drainage emission, and can cause subsurface water pollution through surface water inflow. Extensive augering also causes surface subsidence problems similar to those created by underground methods. Allowing auger holes to remain visible presents an additional safety consideration, where curious youngsters can gain access.

Dredge and Hydraulic

Sand and gravel operations are conducted in most every state. Usually of short duration and small area disturbance, abandoned sites are scattered throughout the country. Impacts of these vacated operations are generally small, and consist mainly of disrupted contour configurations, erosion, and visual displeasure.

Using water directly and indirectly in the mining process, dredging and hydraulic mining have caused very serious stream sedimentation problems during, and after mining. Stream channel disruption and/or relocation over previous settling basins, causes high turbidity and sediment build-ups downstream. Inherent with any wet dredging or hydraulic mining operation are settling or tailings basins. If these basins are not properly "reclaimed" after mining, water erosion of the impounding embankments can cause severe damage and ultimate bank failure, resulting in large concentrated slug discharges of sediment and tailings into receiving streams. Waste disposal dumps created adjacent to original stream channels can contribute to stream pollutional problems for many decades after abandonment.

Deep Well Extraction

Sulfur mining in salt domes, by use of the Frasch process, necessitates leaving the domes with large cavities where sulfur has been removed. As with other near surface underground operations, subsidence is a major problem and creates large, dangerous, unappealing "potholes."

Underground Mining

Underground mining methods, commonly used for a variety of minerals, include: room and pillar, longwall, and shortwall systems, augering, raised bore techniques, deep well extraction (superheated H_2O, similar to Frasch process), caving and stoping methods. These methodologies, although different in their implementation, cause similar types of environmental disturbances upon abandonment of the mine. Used equipment and vacated structures, such as processing plants near mine openings are safety hazards as well as "eyesores." Mine subsidence areas are caused by roof collapse in mined out portions of the mine. Having utilized underground methods that involved filling mine voids with other materials, some vacant underground mines experience little or no subsidence problems.

An impact or terrestrial disturbance characteristic of all abandoned underground mines is the entry area - slope, drift, or shaft. Many abandoned operations allowed these openings to remain, creating safety hazards, visual scars, and mine drainage pollution sources. Surface water can enter these openings and supplement groundwater volume while degrading water quality. Groundwater can also emanate from these holes and degrade surface water quality.

IMPACTS OF ALL MINING TECHNIQUES

A number of environmental impacts have been attributed to the mineral extraction industry in general. These impacts, depending upon topography, geology, climatology, specific minerals involved, and mining techniques employed, may or may not have permanent adverse affects. Impacts resulting from haulage and access roads, drill holes, and air pollution are generally common, at least to a degree, in all mineral extractive industries.

All mining activities, whether surface or underground, require haulage and access roads. Depending on location and materials used for construction, these roads can cause severe environmental disturbances. Many miners used toxic waste materials to construct haulage routes, providing near-permanent toxic emission sources. Being exposed to effects of weathering, abandoned access roads are easily eroded, causing siltation and sedimentation of receiving streams. Nearby community residents, at times take advantage of abandoned mine roads to dump trash and litter on mined lands, thus contributing further to environmental degradation and health hazards.

Exploratory and test holes drilled during the life of the mine and later abandoned, can become pollutional sources as well as public safety hazards. These holes serve as avenues of transport for polluted surface water entry into groundwater aquifers. On the other hand, when these holes intercept flooded or partially flooded mines, they can allow subsurface mine drainage to reach the surface and enter nearby streams.

Abandoned surface and deep mine sites are predominantly viewed as contact areas for dispersal of water borne pollutants, however, they are sources of air pollutants as well. Essentially, environmental degradation due to air pollutants from abandoned mine sites is less significant than the adverse impacts of water contamination. However, any comprehensive plan for abatement of pollution from abandoned mine sites must be considerate of possible air pollution impacts.

Many abandoned surface mine sites, and surface remnants of underground mining operations have been left with little or no reclamation and revegetation. As a result, vast unprotected surface areas remain exposed to the elements. These areas may range in size from an entire unreclaimed surface mine site to smaller wind erodable sites such as dried tailings ponds, spoil and mineral storage piles, and haul roads.

Often, the surface of these areas is reduced through natural weathering to a texture consisting of fine particles which can easily be picked up and carried by air currents. This creates an atmospheric suspension of solids very similar to the suspension of solids in water. Unfortunately, unlike the water transport mode which is limited to the confines of stream beds or other water courses, air-borne material can cover a large area in a relatively short time.

For ease of discussion, air pollutants from abandoned mine sites can be divided into three distinct categories: Inert Particulates, Toxic Particulates, and Gases.

Inert particulates, in the context of this discussion are fine soil particles, inactive chemically, which pose the threat of environmental suffocation. Carried by wind from the mine site, the larger, heavier particulates in this category can be deposited over and suffocate surrounding vegetation. Also, if settling occurs over populated areas, a severe dust problem is often created. Severe consequences can result from extremely fine particulates which do not rapidly settle out of the atmosphere. Remaining in suspension for long periods of time, these particulates may be inhaled by humans and wildlife, causing damage to lung tissues.

Toxic particulates are those which either react chemically with other elements, causing an undesirable end result, or which constantly emit radioactivity. Spoil materials contain salts which can severely corrode any metal surfaces they contact, kill vegetation, and degrade the quality of adjacent waters. Inherent in the spoils and dry tailings ponds of abandoned uranium mines in the West, are radioactive substances. Widespread air transport of these substances could incur long-lasting and devastating environmental damage upon both flora and fauna species.

Although less predominant than the problem of particulates, some abandoned mine sites do generate noxious polluting gases. For decades abandoned "culm" banks in the Nation's anthracite region have been burning and emitting hydrogen sulfide gas. This highly toxic gas, escaping into the atmosphere, is carried to wooded areas, killing vegetation, and to adjacent cities and towns, causing adverse health effects.

Obviously the extent of air pollution or its severity must be assessed individually for each mine site or group of mine sites in a specific area. The amount of unprotected surface exposed to the elements, physical and chemical composition of surface materials, and meteorological conditions are factors which will directly affect the generation of air contaminants. Therefore, a comprehensive delineation of problem areas can only be developed through extensive air quality monitoring programs encompassing specific study sites.

CHAPTER 3

RECLAMATION - ENVIRONMENTAL POTENTIAL

RECLAMATION - ENVIRONMENTAL POTENTIAL

Losses of natural resources caused by lack of reclamation from mining activities are in direct conflict with the growing needs of municipal, industrial, agricultural, recreational, navigational, private and governmental groups. In many cases, absence of suitable land and water resources causes public and private groups to exploit more costly alternatives. The degree of permanent disruption of land and water, relative to their former utility, is dependent on numerous variables: orientation and distribution of the extracted mineral, amount and type of land alteration, volume of mineral per unit surface area, presence of toxic material leached, rainfall, topography, hydrology, natural vegetative cover, size of mineral body mined and proximity to surface (if deep mined), and the resultant surface configuration of the abandoned mine site.

It is important to note that degradation of the air, land, streams, and groundwater may improve slowly and stabilize or seemingly never improve beyond barren land. For example, some abandoned surface coal mines may revegetate naturally where suitable soil, nutrients, and moisture are present, thus eliminating some land deterioration, stream and air pollution. On the other hand, toxic spoil banks and large coal refuse piles show practically no improvements. Numerous mines are continuous sources of pollutants, such as ferrous hydroxide and high concentrations of dissolved salts, which severely pollute thousands of miles of streams. Disturbances to land and water may vary greatly in nature for a single mineral commodity and mining method as well as between mineral commodities, mining methods and regions of the country.

By 1971, about 40 percent of all land disturbed by surface mining was reclaimed to some extent, the remaining 60 percent is totally unreclaimed. An estimated 1.46 million hectares (3.6 million acres) of land was disturbed by these mining operations with the following breakdown indicating the percentage acreage affected:

coal	41%
sand and gravel	26
stone	8
gold	6
phosphate	6
iron ore	5

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clay	3
other	5
(surface mined minerals)	

The distribution of disturbed lands by commodity differs somewhat between minerals and is related to the type mineral deposition, proximity to buyer, and consumer demand. Abandoned surface mined coal lands are situated predominantly in Illinois, Indiana, Ohio, Pennsylvania, West Virginia and Kentucky. Stone, clay, and sand-gravel have been mined throughout the United States and are generally associated with population centers and consumer demands.

Elimination or reduction of environmental degradation to the land and waters can be approached through implementation of at-source preventive abatement measures or treatment - the two primary types of pollution controls. Preventive pollution abatement measures - for example, deep mine sealing, surface regrading, and revegetation - are commonly implemented at abandoned mine sites. Preventive measures usually require one initial expenditure, and no follow-up management or supervision. This represents a sound economic investment in terms of benefits accrued with time and little or no continuing costs. Treatment measures, however, are usually utilized only at active mine sites with treatment cost being incorporated into the selling price of the product. Treatment requires high capital investments, and on-going labor, maintenance and materials costs. Benefits from this approach (clean unpolluted streams) last only as long as treatment is applied and cease if treatment stops. Occasionally sufficient benefits can be realized to economically justify infinite treatment of abandoned mine drainage. Such justifications may include recovery of large sections of a stream having marginal water quality, thus providing additional sources of drinking water and recreation facilities to a region having no alternative sources.

The abandoned mine site's reclamation potentials, specifically water or land-oriented utility is primarily dependent on mining method used, soil and water conditions and available reclamation materials. Effectiveness of abatement measures and their costs are directly related to the desired post reclamational land and water uses. The land use priorities and adequacy of pollution controls or abatement measures are subjective and must be evaluated employing a logical and systematic approach.

Approximately 80 minerals have been surface and deep mined in the United States and discussions of the impact, reclamation potential and land and water use restrictions for all minerals and mining methods goes beyond the scope of this report. Fortunately the major impact from abandoned mines involves only a few minerals utilizing similar mining methods, enabling a discussion of the reclamation potential of these lands.

Most land and water restrictions imposed by mining disturbances can be resolved by proper reclamation at justifiable costs. However, severe subsidence problems or large discharges from mining operations are not as easily solved and research is still in progress. Reclamation potential and success cover the full spectrum from restoring the land and water to its original use to providing land or water use in a higher demand than its original form. An excellent example of improved land utilization through reclamation is flat pasture land in mountainous eastern Kentucky, created by the mountain top removal mining method. This mountainous land had little value before mining, but increased in value immediately after reclamation.

Benefits commonly realized through successful reclamation and abatement of pollution are both stream and land oriented. Stream or water oriented benefits are generally associated with recreation and aesthetics, fishing, water fowl hunting, reduced structural damage (corrosion), reduced water treatment costs, increased industrial and public usability of the water source, greater reservoir capacities due to reduced siltation, reduced flooding, and reductions in corrosion to buried transmission lines. Land oriented benefits include increased value or selling price of land, greater tax base, availability of saw timber and pulp wood, recreation and aesthetics, improved big and small game hunting, commercial and private building sites, agricultural crop and grazing land, and refuge and feed areas for wildlife.

In planning reclamation of an abandoned mine site, full advantage should be taken of the altered topography at the site to develop the land for its best potential use, such as creating useful impoundments, shelter areas for grazing land, home sites and access roads to aid travel for fishermen and hunters. However, the success and maximum benefit from a reclamation project can only be achieved if the total watershed problems are understood and considered. This will hopefully eliminate cosmetic relief or limited success resulting from other limitations imposed by either non-mining related pollution or additional mining pollution sources within the watershed.

Justification for reclamation expenditures is usually determined by cost-effectiveness and benefits achieved. Projects low in cost effecting removal of large amounts of pollution, gaining multiple land and water uses, receive high priority. Costs associated with specific reclamation benefits depend on initial suitability of the disturbed area for that land or water use. A major portion of the reclamation cost can be offset by the benefits achieved within 30 to 50 years. However, in some cases benefits have offset costs in a few years; such as for high demand recreational and residential or industrial site development projects. Benefits from reclamation projects are not necessarily restricted to the reclaimed mine site; nearby lands and streams may accrue additional multiple uses. For example, studies of reclamation work in the Susquehanna River Basin have indicated stream and land oriented benefits amount to a return of $1.27 for every dollar spent.

NATURAL CHARACTERISTICS AFFECTING LAND UTILITY

Once initial land disturbance occurs, natural factors influence future land utility. Method of mineral extraction and subsequent abandonment sets an initial determining factor to be reckoned within any reclamation plan - configuration of abandoned land. Socio-economic considerations determine funding and the desired end result of reclamation. The following parameters set a framework constructed by nature within which land planners must operate:

1. Soil
2. Geology and Mineralogy
3. Hydrology and Water Quality
4. Topography
5. Climate

Soil

Quantity and quality of soil influences land use. The amount of soil present at the abandoned mine site may be sufficient for woodland or pasture, but not agricultural products. Nutrients such as nitrogen, phosphate, and potash, and parameters such as grain size (which will affect permeability and porosity), chemical composition, organic content, color, and pH determine what species of vegetation will grow successfully and how much precipitation will be absorbed into the ground.

Geology and Mineralogy

Physical geologic parameters and rock type of surrounding geologic formations play an important part in future land use planning. Presence of numerous faults and joint systems could eliminate any sort of landfill plans. Analysis of local structural geology will indicate subsidence potentials, mine sealing feasibility, and how the attitude of beds, faults, joints, fractures, porosity, permeability and current deformation forces affect hydrologic conditions and highwall and slope stabilities. Unsatisfactory geologic conditions could eliminate home building and industrial parks as land use choices, but be of little consequence concerning agricultural or grazing potential. Mineralogic characteristics of surrounding rocks influence future mining feasibility as well as natural pollution potential or neutralizing capabilities.

Hydrology and Water Quality

Hydrologic conditions and water quality strongly affect any water related reclamation proposals. A sufficient water supply of adequate quality must be available. Land erosion by flowing waters should be considered. Any land use plans should avoid contaminating aquifers. Hydrologic conditions associated with deep mining of coal may not allow installation of mine seals at pollution sources because of build-up of excessive hydraulic heads.

Topography

An important topographic impact on an area's utility is accessibility. If terrain is too steep, farm machinery may be unable to function properly. Industry and home developers may shy away from an area because adequate transportation routes by-pass mountainous areas, as is the case in parts of Appalachia. However, disturbed land regraded to a gentle rolling topography in mountainous regions commands high demand for uses ranging from agriculture to housing developments. In many cases, a land use plan calling for contrast with regional topography in an aesthetically pleasing manner may be most viable.

Topography also influences erosion, slope stability and flood conditions.

Climate

Climatic conditions such as annual normals, means, and extremes of temperatures and precipitation affect species of vegetation considered for planting, planting time, number of plantings per year, length of growing season, and yield per acre. Disturbed land subjected to extremely hot, cold, or dry conditions, such as Alaskan tundra or southwestern deserts, may lack any immediate utility other than wildlife habitats. Reclamation becomes difficult and costly, but necessary if we wish to pass on a healthy environment to future generations.

MINING DISTURBANCES AND RECLAMATION POTENTIALS

Keeping these above-described nature factors affecting reclamation potentials of an abandoned mine site in mind, specific mining methods will be discussed as they relate to potential land and water use. Land use potentials are also summarized in Table 3-1.

Open Pit

Many abandoned open pit mines and adjacent processing areas, especially the large iron ore and copper ore pits, exhibit low reclamation potentials due to the enormous size and depth of operations.

The larger pits cannot be backfilled because too large a volume of mineral has been removed. However, if high demand for adjacent

Table 3-1

MINED LAND UTILIZATION POTENTIAL

MINING METHODS	LAND USES											
	Agricultural	Pasture	Timber & Pulp	Open Space (Forest etc.)	Wildlife Habitat	Recreational Park	Water Related Recreation	Reservoir	Home Development	Industrial Park	Commercial Building Site	Sanitary Landfill
OPEN PIT												
Metals	3	3	3	1	1	2	1	1	3	2	3	2
Non-Metals	3	2	3	1	1	2	1	1	2	2	2	1
AREA STRIP	1	1	1	1	1	1	1	2	1	1	1	2
CONTOUR STRIP	2	1	1	1	1	2	2	3	2	2	3	2
MOUNTAIN TOP REMOVAL	1	1	1	1	1	2	3	3	1	2	2	3
AUGER	2	1	1	1	1	3	3	3	3	3	3	3
DREDGE	2	2	2	1	1	1	1	2	2	2	2	3
HYDRAULIC	3	2	2	1	2	2	2	3	1	2	3	3
UNDERGROUND	2	2	2	1	1	2	2	3	3	3	3	1
DEEP WELL EXTRACTION	2	1	1	1	1	2	3	3	3	3	3	2

KEY

1 High Probable Use
2 Probable Use
3 Low Probable Use

land exists, disposal of waste and tailings into the pit, slope reduction, and revegetation of waste areas and pit slopes may be feasible. Coal, phosphate, sand and gravel, and stone open pits and quarries generally disturb a much smaller acreage than the larger ore type pits, and because of transport economics are usually located near populated areas. Higher demand affords greater reclamation potentials.

Water quality associated with these non-metallic industries is generally higher. Swimming, fishing, and other water related activities can enter reclamation plans. Gently sloping underwater safety benches should be constructed as safety precautions if swimming is desirable. Parks, picnic areas, and playgrounds may be practical. In crowded eastern areas, industries requiring a sizeable water supply may wish to utilize adjacent lands as an industrial park and fence the area as a safety precaution. Communities may utilize wet pits as reservoirs. Again, depending on location, an adjacent planned housing community may be able to utilize an abandoned open pit for a water supply and recreational facility. When hydrologic conditions permit, the pit has the potential of a ready made solid waste disposal site.

Area Mining

Reclaiming area mined land involves grading the sharp crested spoil into adjacent valleys. Regrading to a gently rolling topography or approximate original contour is usually desirable. If agricultural utility is intended, boulders should be buried and slopes made gentle enough for operation of farm machinery.

Water impoundments formed in the final cut may be a valuable water source for agriculture, livestock, and recreation, if it is not chemically polluted or laden with silt.

Since area mining is most applicable to relatively flat-lying regions, good reclamation grading, soil conditioning, and revegetation can restore disturbed land to a condition virtually indistinguishable from the surrounding landscapes, whether it be agricultural land, pasture, or forest. Midwestern companies have constructed park and lake areas in dry regions where old spoil piles once stood. A variety of reclamation potentials include agriculture, pasture, timber and pulp wood, recreational parks and lakes, industrial parks, planned housing communities, sanitary landfills, shopping plazas, and office complexes.

Contour Mining

Although the techniques are different between area and contour mining the abandoned land does offer similar reclamation potentials. Backfilling bench areas, covering or partially covering the highwall, and possibly highwall reduction (although more acreage becomes disturbed) helps alleviate the problems resulting from past contour mining abuses. New utilities may be realized from formerly unproductive, inaccessible woodlands. Backfilling and soil treatment can provide pasture land in locales where none exists. Select tree planting can provide good timber or pulp wood. If located outside urban areas, it may be desirable to retain level bench areas for private home construction.

Mountain-Top Removal

Extensive mountainous areas are leveled, creating large tracts of flat land. The same reclamation potentials exist for land affected by mountain-top removal as exist for area mining; although demand for homebuilding sites and pasture land would have higher priority.

Auger

Augering involves disturbances of small acreage and has a relatively negligible effect on land utility. It is usually associated with some other form of mining such as contour stripping.

Dredging

The relatively large body of water left behind upon abandonment offers excellent reclamation potential for recreation, home sites, industry, or reservoirs for domestic or agricultural uses.

Underground

Underground mining activities disturb far less acreages then surface methods. Room and Pillar, Longwall, Shortwall, Stoping, and Augering methods cause one similar land disturbance problem - subsidence. Treatment facilities capable of neutralizing mine drainage have effectively restored many miles of streams for swimming and fishing, but require continual operation, maintenance and, unfortunately, funding.

LAND VALUES AND TAXES

Value of abandoned or reclaimed mined lands as utilized in this section is defined as being the highest selling price for a parcel of land made available on the open market for a reasonable period of time. The value of the land (less minerals), is controlled by inflational increases and potential land use benefits which govern the selling price and tax benefit values.

The value of unreclaimed abandoned mine land and reclaimed land is controlled by supply and demand, as is true for other land uses. Areas that are not easily accessible or are far removed from population centers with few or no paved transportation routes have relatively less value. This is common for many abandoned coal and metal mines, however, sand and gravel operations are usually closer to population centers and have a higher demand and sale value. The resultant topography of the land and its condition relative to any intended use the buyer may have greatly controls purchase price. Size and shape of land tracts do not always have an impact on sales value except when the use demands a minimum acreage. If the unreclaimed or reclaimed land has an adequate supply of water with acceptable quality, values are usually greater. As is true for other benefits the selling value of reclaimed land can be decided by the appearance and condition of surrounding land.

Many surface mined lands have been reclaimed or used for public recreational purposes, pasture lands, landfills, pulpwood, saw timber, crop farming, shopping malls, and residential sites. All of these uses are considered as high value and have a positive economic impact on the area. Excellent commercial uses do occur but are too dependent on the presence of heavily traveled highways and built-up urban areas not commonly found near many abandoned coal and metal mined lands. Often the purchaser of a tract of abandoned mined land owns adjacent acreage and seizes the opportunity to increase total land holdings.

It should be emphasized that abandoned mine land in extremely steep sloped and dry arid areas has little utility and hence little resale value. Some mining practices also leave land in a rather useless state. Large open pit mines where a large volume of material has been removed offer little utility other than possible water reservoir usage.

A survey of coal surface mines conducted in the state of Ohio appraised the value of unreclaimed and reclaimed land. This survey also ascertained the primary reasons for land values to be lower and higher than normal. The normal range of sale prices per hectare for unreclaimed land was found to be $247 to $371. Reclaimed land was found to sell for $371 to $618 per hectare. The value range was considerable and reasons for this are mentioned below. Adjacent land owners who purchased unreclaimed land or reclaimed land were usually offered this land to increase their holdings at a relatively high price verging on speculative buying. A first choice offering was usually made by owners who could not acquire higher selling prices from absentee buyers. The highest dollar per hectare transactions occurred when excellent commercial land use was anticipated. The lowest prices were paid for extremely remote and rough land where mineral rights were retained. The presence of water and recreation potential increased selling prices consistently.

Within Pennsylvania's central bituminous coal fields rough mountain land adjacent to strip mines usually sells for $494 to $741 or less per hectare. Similar unmined natural land at a distance from strip mines and unaffected by other industries often sells for $1,483 to $1,730 per hectare. This land is high in demand for cabin sites in Pennsylvania's best deer hunting areas.

Reclaimed mined lands greatly increase the tax base of the local community. These revenues are generally used to provide improved local government and services. Other state oriented tax benefits can result from sales of produce such as farm crops, milk, saw timber and numerous other taxable items. Private, industrial and commercial land and its use are all local sources of taxable income. However, public ownership of land (for example landfills and recreational areas), is not taxable and increased income to local governments must be acquired from fees charged to persons utilizing these facilities.

Local or county taxes are acquired from a percentage assessment of the market value and the millage rate applied. County agencies responsible for taxes, land assessments and real estate transactions can provide necessary information to state planning groups from which land value and tax benefits can be determined. One central Pennsylvania county within the bituminous coal fields realized market value increases of $618 to $988 per hectare for reclaimed land. The county applies a 67.5 millage rate against an assessed value taken at 40 percent of the market value. This represents an annual tax increase of $9.88 per hectare. State taxes on produce bought could be determined from the land use, acreage and productivity. Returning utility to the land has other economic benefits related to employment, less welfare, lower prices resulting from increased supplies and general increases in sales and services.

A federal study conducted in 1965 assessed surface mined lands and their success for rehabilitation to specific land uses. Estimates of land use potential were provided by field personnel of the Soil Conservation Service and Bureau of Sport Fisheries and Wildlife. Land uses, areas and the percent of total lands reclaimed for all uses are presented below.

Land Use	Hectares (thousand)	Percent of Lands Reclaimed
cropland	17	2.1
forest	188	22.8
occupancy	49	5.9
pasture	98	11.9
ponds - lakes	59	7.2
rangeland	94	11.4

recreation	88	10.6
streams	55	6.6
wildlife	178	21.5
Total	826	100.0

About 25 percent of all mined land is considered to have some form of agriculture potential. The relatively low percentage value for cropland is mainly due to lack of adequate soil and topography. The geologic setting of many eastern and western coal basins is not conducive to crop farming. Thin soil horizons are often found overlying resistant sandstone units whereas areas with shale outcroppings are more likely to have reclaimable soil cover. The mid-west or Interior Coal Province states offer the greatest potential for crop farming. All crops require adequate rainfall, nutrients, nearly level slopes and a minimum growing season. Truck farm crops require prime agricultural land and are of high enough value that irrigation can be used. Most crops planted in large quantities depend on rainfall and can not justify costly irrigation. Average quality agricultural land can be used for hay, pasture, potatoes, small grain buckwheat and other similar crops. The poorest quality agricultural land is used only for pasture land.

Historically, crop values have fluctuated widely. Price has been dependent on droughts, both local and worldwide, government controls and export prices. Corn, alfalfa, wheat, and oats, for example, currently have gross average annual values per hectare of $309, $247, $198 and $185 respectively. If crops are used as feed for beef, pork, and poultry, for example, this increases the average gross annual value of about $41 per hectare annually.

Other than the mid-west and selected areas within the Appalachian states little prime agricultural land exists within the coal measures. The anthracite fields of northeastern Pennsylvania, covering 1270 square kilometers (489 square miles), have practically no agricultural potential, including pasture land. Within the bituminous coal fields of that state two to three percent of abandoned mined lands can be rehabilitated to agricultural use. A greater percentage is possible at higher reclamation cost.

Some agricultural uses are primarily dependent on the land itself. Other uses requiring stock watering are dependent on water supplies with very limited pollution. For example, acid mine drainage severely limits dairy farming. The effects of contaminants on irrigation are not clearly understood and no doubt would depend on the crops, soil and frequency of watering and concentration of pollutants. Such pollution is limited to areas in Appalachian states and does not constitute a real problem in the fertile midwest cornbelt region.

Agricultural lands possess one great advantage over some other land uses. Agricultural benefits are high relative to other single benefits. Agricultural lands accrue other benefits as well, including big and small game hunting, recreation and aesthetics, wildlife refuge and home sites. The 2 percent assessed by the federal study could be increased justifiably in light of the high agricultural benefits and multi-land use advantages. The desirability for extra reclamation cost for rehabilitation to agricultural use must be weighed with other land uses, their demand and benefits accrued.

BENEFITS DERIVED FROM LAND AND STREAM RECLAMATION

Benefits derived from cleaning polluted streams and reclaiming surface mined lands can be clarified by listing the various effects which detract from the utility of streams and land. The immediate effects mine drainage pollution has on surface and subsurface (groundwater, springs) is, in many cases, lowered pH, reduced natural alkalinity, increased total hardness, iron, manganese, aluminum, sulfates, siltation, and the presence of other dissolved and suspended solids. Estimates of the range of dollar value losses associated with these conditions for specific benefit categories are discussed in the following sections.

One of the most pollution sensitive water uses is fishing. Damage to fish and fish food organisms is usually caused by high concentrations of acid, iron, sulfate, salt precipitates and siltation. Some coal and metal mine drainages discharge zinc, copper and aluminum in lethal concentrations. Damages caused by stream pollution go beyond the destruction of aquatic life and discoloration of water. Industrial, municipal, and some agricultural stock and irrigation water supplies may also be affected. In water treatment plants, high acidity and low pH may result in adverse effects on chemical coagulation, softening, and corrosion control. Telephone and electrical services are seriously hampered when pollutants contact buried transmission lines. Corrosion of lead shields and loss of conductivity can be caused by acidic drainage. Both iron and manganese create problems in public and some industrial water supplies. Salts of these metals stain plumbing fixtures and laundry and interfere with some industrial processes. Iron may support a filamentous bacteria growth which clogs distribution lines. Pollution can cause increased water hardness, which creates a need for water softening equipment. Permanent hardness affects boiler feed water, cutting down heat exchange created by scaling. The greatest water need by industry is for cooling water. Acid water consumed by dairy cattle seriously affects milk production in addition to causing some irrigation problems.

Most water related damages are caused directly by underground mine discharges, some of which have their flows augmented by overlying surface mines. On a nationwide basis it has been estimated that only 20 to 25 percent of all water pollution is associated with the surface mine. Consequently most benefits derived from cleaning streams will have to result from abatement of deep mine drainage, much of which can not be economically treated. Land oriented benefits will result mainly from reclamation of abandoned surface mines. Disturbances to the land include unstable slopes, erosion and stream siltation, exposure of toxic material, lack of soils, improper drainage, high infiltration, formulation of impoundments which may be useful, steep topography, and no vegetative cover including feed and shelter for wildlife.

Reclamation or rehabilitation of abandoned surface mined lands and surface waters can be achieved for nine basic land water uses: 1) crop land; 2) forest; 3) occupancy; 4) pasture; 5) ponds and lakes; 6) rangelands; 7) recreation; 8) streams; and 9) wildlife areas. Restoration of lands and streams for these uses requires the reclamation practices outlined below.

Land Use	Reclamation
Croplands	grading to nearly level topography, segregation and burial of large rocks, spreading finer material and organic matter on surface, providing adequate drainage control, soil conditioning and planting.

Pastureland	grading for proper drainage and slope not exceeding 15 percent to permit safe use of equipment to harvest forage crops, soil spreading and conditioning, and planting.
Rangeland	strike-off grading, impoundment formations, planting.
Wildlife Areas	some grading, erosion controls, drainage controls, water-hole and wetlands development, access road building, and game food planting.
Ponds	some grading, erosion and sediment controls.
Occupancy	intensive grading, compacting material, soil spreading and conditioning, erosion and sediment controls and some planting.
Streams	stream bank grading, erosion and sediment control measures, spawning area development, and riprapping.

An evaluation or estimate of benefits accrued by performing the abovementioned rehabilitation is discussed below for various benefit categories. Other methods of estimation could be used and are not limited to those mentioned.

Benefits accrued by restoring lands and streams for hunting and fishing are measured by the expenditures of money by people actively engaged in these activities. Estimates of these costs or benefits are usually made periodically by state game and fish commissions (who keep detailed records which assist such surveys). The United States Department of the Interior's Bureau of Sport Fisheries and Wildlife conducts a national survey of fishing and hunting every five years. The last survey (fourth) was conducted in 1970 and the results of this survey are discussed on the following pages.

Fishing and Hunting Benefits

In 1970, about 128 million persons participated in various forms of outdoor recreational activities in the United States. Among these activities fishing and hunting were ranked very high. The survey determined that almost 55 million persons spent 780 million recreational days fishing and hunting. As defined by the survey, "a recreational day is a day any part of which was spent fishing, hunting, or involved in other forms of recreational endeavor." During 1970 some 30 million fresh water fishermen spent 3.7 billion dollars on 592 million recreational days, or $6.30 per day. Small game hunters, numbering 11.67 million, spent nearly one billion dollars on 124 million recreational days, or $7.62 per day. About 7.8 million big game hunters spent nearly 1 billion dollars on 54.5 million recreational days, or $17.47 per day. Other recreational activities included 411 million days bird watching, 39 million days photographing wildlife, and 337 million days hiking.

The percent of people fishing in the nine regions designated by the survey ranged from 14 to 31 percent with a mean of 22 percent. Percentages for hunting ranged from 6 to 17, with a mean value of 10.3. To assign a dollar value to an acre of restored land the number of recreation days spent in a year per acre can be estimated according to the demand for the activity. Reclamation of surface mined land also provides increased hunting potential and benefits on adjacent lands. Benefits are usually presented as annual accumulations of dollars spent or saved. To justify costs for reclamation work which provides on-going benefits more than one year's benefits should be totaled. It should also be emphasized that providing more outdoor recreational opportunities reduces travel time and fuel consumption which might otherwise not be conserved. The National Survey's dollars were spent for clothing, food, lodging, auto expenses, licenses, guns, and many other miscellaneous items.

Recreation and Aesthetics

Benefits associated with recreation and aesthetics may not always be easily determined; however, insights are provided below for one possible method. Recreational benefits could be determined for a variety of activities pursued and associated attendance figures for a season. Determining dollar values for aesthetics is more difficult. Aesthetics plays a very real and important role in cost determinations and decision making. For example, mass urban to rural movement, location and visual quality increases in real estate prices, attendance at art museums, national parks and forests all testify to our common everyday interest in aesthetics.

A purely objective monetary evaluation of aesthetics is extremely difficult, and perhaps never to be achieved without assumptions being made. Aesthetics can best be evaluated using known dollar relationships with activities associated with the pure enjoyment of nature. This in turn can be associated with the price citizens are willing to pay to restore mined lands and polluted waters to an aesthetically appealing condition.

A general relationship between dollars and aesthetic values was derived from data collected by the Fourth National Survey conducted by the Department of the Interior in 1970. Three forms of recreational and aesthetic related activities were surveyed: nature walks or hiking, wildlife photography, and birdwatching. During 1970, throughout the United States, 26.9 million persons spent 337 million recreational days nature walking. About 4.52 million persons spent 37.83 million days photographing wildlife. Another 6.8 million persons spent 411.4 million recreational days birdwatching. All of these recreational activities are directly associated with the enjoyment or the perception and appreciation of nature. These activities all require expenditures for equipment, transportation and food. The expenditures for these items is approximately equivalent to an average $80 per year spent by persons involved in other forms of outdoor recreational activities. On a national basis at least 786.3 million recreational days were spent during 1970 on purely aesthetic activities. This compares with only 178.6 million recreational days spent big and small game hunting during 1970. The larger number of recreational days spent on aesthetic type activities is mainly due to the lack of time restriction or open seasons. Aesthetic type activities can be enjoyed 12 months of the year in many areas, as opposed to about two months for big and small game hunting limited to certain areas. This fact increases the aesthetic value of one hectare of reclaimed land on the basis of time alone. Within the state of Pennsylvania a recreation and aesthetic benefit value of $74 per hectare per year (or only $0.20 per hectare per day for all persons enjoying such benefits) was estimated. Reclaimed lands also greatly enhance the aesthetic appeal of adjacent areas.

Stream Non-Fishing

Stream non-fishing recreational and aesthetic improvement benefits can be computed on a basis similar to the abovementioned land improvement aesthetic benefits. Justification for development of this benefit is presented below. A polluted stream is innately unappealing to most people. As a consequence, little recreational uses occur on or in the vicinity of the banks of polluted streams. Waterfront values along the banks of polluted streams are far below similar stream bank land values for non-polluted streams. The recreational potential is minimal as long as the stream is polluted. This is evidenced by the number of recreational (second) homes on non-polluted versus polluted streams.

A non-fishing recreational and aesthetic improvement value of $74 per hectare per year is assigned to stream bank land. Assuming that this improvement benefit could be applied within 183 meters of both sides of reclaimed stream, this yields 358 hectares of land per mile of reclaimed stream. The applicable benefit value would be approximately $2,709 per kilometer of reclaimed stream per year. As is true for other benefits, values can vary according to supply and demand factors. Transportation networks and proximity to population centers are important and related to supply and demand.

Stream Sediment

Sediment in streams is often tolerated for long periods of time in many areas until hardships or damages become too great. Restrictions in stream channels filled with sediment often cause flooding during high flows through the blocking of channels. Navigational obstructions are also caused by excessive sediment. Sediment reduces reservoir capacities, and seriously affects aquatic life. Siltation of streams is one of the most widespread pollution problems in the United States, but the greatest sources are not associated with surface mined lands. Urbanization, farming, road construction and other forms of land disturbance yield greater concentrations of sediment.

Some surface mines are larger sources of stream siltation while others apparently stabilize or even trap sediment before it enters a stream. Past surface coal mining practices in mountainous eastern Kentucky and West Virginia contributed some of the largest sources of stream sediment. Some forms of surface mining, namely dredging and hydraulic mining are far greater sources of sediment during mining.

Most streams eventually discharge into large lakes and bays which can be adversely effected by sediment transported from surface mined areas. Most stream siltation resulting from abandoned surface mines is associated with contour strip mines and area mines. The majority of such mines extracted coal in Appalachia and the midwest and the eastern predominantly contour mine area is the greater contributor of the two. One large Appalachian watershed conveyed an above normal annual average of 1.9 tonnes of sediment per hectare from abandoned surface mines. Far greater tonnages were recorded in some areas while still other regions of the watershed conveyed less. Average annual sediment yields in heavily strip mined areas of Appalachia are 499 to 590 tonnes per square kilometer.

Benefits associated with less sediment in streams are difficult to fully assess. Both private and public groups can benefit in numerous ways from reductions of sediment. The U. S. Soil Conservation Service commonly justifies expenditures of $1.10 per tonne of sediment removed. In some special cases expenditures from $2.20 to $4.41 per tonne can be made. Hence, for each hectare of contour surface mined land reclaimed, a conservative value of $2.10 per hectare per year can be applied to offset reclamation costs.

Timber Sales

Abandoned surface mined land with potential for forest land reclamation were estimated at 188,186 hectares or 1,880 square kilometers. In 1965 most of this land was within Appalachian states and portions of the mid-west which also have large areas supporting grasses, shrubs and farm crops. Forest land benefits are not only associated with saw timber and pulp wood sales. This land is of value for stabilizing soil cover reducing erosion and sedimentation, providing wildlife refuge areas, improved small and big game hunting, as well as recreation and aesthetic uses. Some forest lands are cleared primarily for pulp wood and saw timber although some land may be cut for pulp wood alone.

Benefits associated with saw timber must accumulate over a period of 60 to 80 years depending on the number of years required for a use maturity. The climate and species of trees are important controlling factors. If a well managed stand of timber yields typical lumber volumes, the landowner could receive $741 to $1,235 or an average of $988 per hectare over a 70 year period ($14.08 per hectare per year). Other benefits to saw mill owners associated with a stand of timber include additional sales of slab wood for firewood and raw material for paper mills and use in other products. Premium prices are paid for veneer quality hardwood logs.

The laws of supply and demand control those benefit values. In past years saw mills in the eastern United States were transported to a site for a few years of cutting and then moved to a new area. Presently mills are more stationary and depend on a sufficient quantity and quality of logs being hauled to the mill from numerous cutting sites relatively close to the mill. As haulage distances become greater the cost of logs increases and the mill may shut down permanently or be moved. Other factors may affect the benefits of reclaiming one hectare of abandoned surface mined land to forest use. The $14.08 per hectare per year value is average for mixed soft and hardwoods maturing in 70 years in accessible regions of Appalachia. Other benefits, as mentioned above, are applied to reclaimed forest land and can be accrued sooner than the first cutting of trees.

Industrial Processing and Structural Damages

Historically large population centers with economical dependence on industry have formed along coastal areas and rivers throughout the United States. The continued economic well being of these communities and those they serve is extremely dependent upon a plentiful and readily available supply of water, with quality suitable to meet industry and public everday needs. Nationwide, the greatest industrial water needs are for production of electrical power, a demand which is nearly doubling every ten years. The electrical utility industry requires about 70 percent of all water currently withdrawn for industrial use. Iron and steel production, chemical and allied products, paper products and petroleum refining, combined, use another 20 percent with the remaining 10 percent being used for other diversified products. Industry's greatest single use of water is for cooling in production of electrical power.

Most industries design their new production facilities to either avoid or cut costs incurred in using polluted water, including any treatment. Water is often recirculated or used less. For example, older steel mills used as much as 378,500 liters of water to produce a tonne of steel while more modern and efficient plants only use 5,420 liters per tonne of steel. Most water withdrawn for industrial use is returned to waterways and only 6 percent is actually lost or incorporated in the product.

Industrial water use is increasing substantially. Since the turn of this century, industrial water use per capita has increased six times. Although streams carry more than an adequate volume of water even for future needs, some areas may not have enough water of suitable quality. Industry obtains 90 percent of its water from surface streams, which are more prone to direct pollution than are other sources. The remaining ten percent comes from groundwater and public supply sources. Many factors determine the source each industry draws upon: quality, quantity, transport distances, dependability of supply, and other plant oriented considerations.

Needs for good quality water go beyond avoiding extra expense by industry to minimize plant facility damages. Damages occur to dams, bridges, conveyance systems and other structures which cannot tolerate acid waters or other forms of pollution unless costly corrective measures are taken.

Estimated costs of damages, water treatment, and materials which tolerate the corrosive attack of pollutants are difficult to fully determine. A large number of municipalities, industries, and government agencies with varying types of pollution problems do not always make a retrievable or separate record of these extra costs. Extra costs to industry, although a substantial sum of money, are usually insignificant relative to total production costs. On the average, only 2 percent of the sales cost is associated with water use, and only 3 percent of that cost is incurred in handling polluted water. Electrical generating plants, on the average, have the highest additional costs due to acid mine drainage, at 0.5 percent of annual production cost. Many existing companies are not plagued economically by coping with pollution problems because all extra cost are incorporated in the selling price of the product. New industries have more to gain by building near unpolluted water sources.

Estimates of benefits or annual savings from projected increases in water use alone could over-estimate benefits or savings for several reasons. Volume of water used is not proportional to costs incurred by industry for handling polluted water, and future technological developments are providing new materials and techniques for industry which reduce cost of handling polluted waters. For example, electric generating plants presently under construction average an additional $203,000 due to acid coal mine drainage, and future plants constructed about 1990 will cost only an additional $164,000, based on equivalent dollars. Although costs to industries would be reduced due to new technological innovations, increased costs to industry, in general, from greater production and new industries could have a compensating effect.

Benefits related to structural damage or its avoidance is a function of the amount of water consumed, magnitude of the problem created, material expenses to avoid problems, treatment cost and the number and type of facilities and structures effected. Among those industries adversely affected by polluted waters (most to least) are electrical, food processing, textiles, chemicals, paper, metal and glass. There are a great number of water quality standards for public water consumption and use, with drinking water having the higher standards. Standards for process water also exist for industry. For example, the pulp and paper industry has several different standards for fine paper, groundwood paper, bleached and unbleached. The textile industry has a range of threshold values (See Table 3-2) for 13 water quality parameters commonly found in process water.

Estimates of benefits related to industrial processing, drinking water and structural damages begin with the determination of water quality parameters relevant for each user, range of recommended threshold values for each parameter for a specific use, users affected, and extra costs they incur. Intake water quality records can be gathered from various users and sources of the pollutants determined by an extensive stream water quality sampling program associated with a mined lands inventory.

Further, local, state and federal highway bridge departments can be contacted in areas known to have acid streams, pH values less than 5, where corrosion of pipes, culverts and other structures are known to occur. These groups can provide estimates of additional cost to maintain or replace these structures or the additional cost of utilizing corrosion resistant materials. Although water quality improvements, namely less acid, are readily achieved by treatment, this

Table 3-2
RECOMMENDED WATER QUALITY IN
THE TEXTILE INDUSTRY

Constituent	Range of Recommended Threshold Values, mg/l
Hardness as $CaCO_3$	0-50
Iron	0.1-1.0
Manganese	0.05-1.0
Iron and manganese	0.2-1.0
Turbidity	0.3-25
Color	0-70
Chemical oxygen demand	8
Heavy metals	None
Calcium	10
Magnesium	5
Sulfate	100
Chloride	100
Bicarbonate as $CaCO_3$	200

Adapted from Reference No. 83

form of pollution abatement is not a complete solution. Neutralization with lime, which is more common, increases dissolved solids concentrations, thereby adding a potential problem to water users. Preventive abatement measures are more desirable from a cost and water quality standpoint but are less effective in some cases. Benefits accrued from pollution reductions can only be assured when all of the factors are considered and carefully evaluated.

PRIORITIES AND COST

Establishment of priorities is one of the most important planning phases to be accomplished. It should be done before more detailed feasibility studies, project engineering and construction are undertaken. Priorities are often developed from three major considerations: 1) cost of abatement; 2) its effectiveness in terms of specific pollutant reductions or utility restored and; 3) total benefits achieved. Although these considerations are of foremost importance in determining priorities, other factors may cause priorities to be shifted. For example, if industry has secured a mining permit for a known problem area and will re-affect the source area, responsibility may be placed on the mine operator to correct the problem. Land ownership and the effect reclamation may have on future mineral acquisition plays a role in availability of land for rehabilitation. In addition, a myriad of legal and financial problems at the federal, state or local level could affect abatement and reclamation priorities.

Abatement or reclamation costs are usually high and far exceed costs of reclamation incorporated into active mining operations. Costs vary greatly from one project to another even though problems may be similar. The greatest costs are associated with material handling, for example, grading and dozing, transportation of topsoil and other material over moderate to great distances. Other costs for soil conditioning, revegetation and clearing and grubbing are somewhat less. Achievement of improved land and water utility and pollution reductions should be accomplished at minimum cost for low cost-effectiveness and high benefit-cost ratios. Establishment of rehabilitated abandoned mined land potential, pollution reductions, reclamation cost-effectiveness and associated benefits is essential for assignment of priorities. Pollution reductions and improvements to land and water utility are not necessarily proportionate to costs. If the land disturbance and resultant pollution is uniform, cost-effectiveness usually remains fairly constant. An example of such a problem area is soil erosion and stream siltation where conditions do not change. Other disturbances, such as acid mine drainage, have a variety of different sources which vary greatly in the type of reclamation and cost required for equivalent pollution reductions.

Reductions of deep mine oriented disturbances, namely chemical pollutants and subsidence, are usually more difficult and costly to abate relative to surface mine related disturbances. Table 3-3 lists ranges of cost and effectiveness for techniques commonly used in controlling coal mine drainage and other surface mined land disturbances

The percentage of effectiveness for treatment techniques is relatively high compared with preventive techniques. It should be stressed that although highly effective, treatment is high in cost (capital investments and on-going maintenance, materials and labor costs). Benefits associated with cleaner streams, discussed in the benefit sections, continue as long as treatment does but stops when treatment ceases. Frequently costs for abatement of pollutants are

Table 3-3
EFFECTIVENESS AND RELATED COST FOR VARIOUS ABATEMENT TECHNIQUES

Techniques	% of Effectiveness	Cost
treatment		
neutralization	80-90	0.03 - 0.34/1000 l.
distillation	97-99	0.1 - 0.86/1000 l.
reverse osmosis	90-97	0.18 - 0.68/1000 l.
iron exchange	90-92	0.16 - 0.67/1000 l.
freezing	90-99	0.18 - 0.85/1000 l.
electrodialysis	25-95	0.15 - 0.67/1000 l.
preventive (at source)		
water diversion	25-75	740 - 4,940/hect.
mine sealing	10-80	2,470 - 49,420/seal
surface restoration	25-75	740 - 7,410/hect.
revegetation	5-25	170 - 665/hect.

Adapted from Reference No. 61

only provided by public funded programs, which have limited funding and time constraints. On-going sources or unlimited funding may be difficult to acquire or assure. The range of costs for treatment is controlled by capacity of the plant and concentration and type of pollutants treated. Larger capacity plants usually have lower unit treatment cost. More than one form of treatment may be used to improve water quality since the efficiency and unit cost of the method may vary. Capital expenditures are controlled by more obvious factors such as plant size, type and back-up systems required and disposal of solid waste.

The range of cost and effectiveness of preventive abatement measures is indicative of the variety and severity of pollution problems. Some surface and deep mine disturbances are minor and easily corrected, while others constitute a major disturbance which can be solved only at extremely high costs.

Control of surface and deep mine pollution problems usually begins with implementation of preventive measures to permanently eliminate the problem (or as much of the problem as possible). Complete or 100 percent effectiveness is usually not required to gain utility of the land and streams, because most uses can tolerate limited concentrations of most pollutants. Threshold values of various pollutants for specific uses should be considered. Returns (benefits) on reclamation investments usually diminish as costs increase. When preventive or at source abatement measures do not reduce pollution to desired levels, follow-up reductions are achieved through treatment if costs can be justified by additional benefits. Application of treatment alone may be the only method applied to abate some large sources of underground mine pollution. Occasionally high costs for treatment can be offset through benefits achieved.

Establishment of reclamation costs after evaluation of mined lands is complete can be accomplished by experienced engineering and consultant groups, which can also fully plan such programs. Of equal importance is development of benefits to match or partially offset reclamation costs. Both costs and benefits are then analyzed to establish priorities.

Two priority evaluations systems and a combination of each have been utilized by local, state and federal agencies to set priorities. The first system is usually appropriate for large watersheds or statewide pollution programs and is described below. The area which is assigned the priority is usually a subwatershed unit with a disturbance affecting the watershed itself and downstream reaches and adjacent lands. Reclamation cost-effectiveness can be categorized as high (most favorable), medium, and low ratings. A highly favorable cost-effectiveness rating can be assigned a value of three and the lowest rating a value of one. Subwatersheds with a rating of three will realize the same relative land and water quality improvements for similar costs. The desirability, need or benefits achieved from reductions of pollution disturbances must also be considered. Coefficients can be assigned to various categories comprising all benefits such as public visibility, economic need, development demand, land ownership and other groupings. The priority value for the subwatershed is calculated by totaling relevant coefficient values and multiplying that value by the characteristic rating. Watershed scores can be compared and further divided into groups. Groups with high rankings indicate where immediate reclamation feasibility studies or reclamation is most desirable.

The second priority ranking system can be utilized for smaller watersheds where detailed studies have determined a full range of reclamation costs and specific improvements. Benefits with dollar values are determined for a full range of categories (some of which are discussed in the benefit section of this report). The benefits are evaluated for known land and water quality improvements. Improvements can usually be achieved by implementation of numerous abatement methods. Calculations can be made to determine priorities or benefit-cost ratios where a small number of parameters permits. If a large number of values must be considered linear-programming techniques can be used to minimize costs and maximize benefits. Computer solutions can then be analyzed for establishing priority rankings.

Both methods discussed above are useful depending on the program goals and the magnitude of the problem confronted. Control of abandoned mine pollution is costly and the correct assignment of priorities strengthens the economy and further insures appropriations for pollution control. Most reclamation is worth doing in terms of benefits achieved with time.

CHAPTER 4

ACTIVE MINE CLOSURE PROCEDURES

ACTIVE MINE CLOSURE PROCEDURES

As the final operation of any mining activity, mine closure requires careful consideration to: minimize subsequent pollution; establish aesthetic scenery; eliminate potentially hazardous conditions; and facilitate future land utilization. Planning for mine abandonment should begin as an integral part of initial mine design and be implemented in conjunction with final reclamation procedures.

By considering mine closure during development planning, many post-mining problems can be eliminated. For example, design of underground mines for down-dip development can facilitate inundation and sealing by lessening the potential hydrostatic head pressure against seal installation. Surface mining operations can also accrue benefits, such as preventing a deficit of spoil for final backfilling through proper planning and management of spoil placement and/or transport during overburden excavation.

Although mine closure is best accomplisned via pre-mine planning, procedures are available to permit effective abandonment of most existing facilities. The following narratives delineate general mine closure procedures as related to particular techniques of mineral extraction.

GENERAL PROCEDURES FOR ALL MINES

There are certain mine closure procedures that apply to all types of mines. Listed below are general measures that pertain to general site rehabilitation rather than the specific area directly affected by excavation and mineral extraction.

1) Remove all mineral stockpiles.
2) Dispose or revegetate waste stockpiles.
3) Remove all trash, equipment, buildings and structures.
4) Backfill all surface depressions.
5) Dewater tailings ponds and backfill.
6) Revegetate all affected land including haul roads and preparation facilities.
7) Construct safety barriers such as fences and impassable flora hedges around hazardous areas.

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Operational steps comprising mine abandonment and closure vary according to type of mining operation. Because of this, the various mining techniques described in this report have been divided into categories to facilitate discussion of mine closure procedures. Classification of mining operations as determined by closure procedures are:

Category 1 - Surface Mines

Area Contour Open Pit Auger	Sub-category 1
Hydraulic Dredging	Sub-category 2

Category 2 - Underground Mines

SURFACE MINE CLOSURE PROCEDURES

This category includes closure procedures for those mining operations where mineral extraction is accomplished at or near the surface, usually involving removal of overburden material. Individual surface mining techniques are separated into two sub-categories in the following discussions.

Selected Mining Methods

Trash and Toxic Material Disposal

Mine closure activities within the immediate vicinity of mineral extraction should begin with cleaning the pit floor. All equipment, junk or trash should be removed to a disposal area or placed in a portion of the pit for subsequent burial. If the latter disposal technique is implemented, precautions should be taken for separating materials that can pollute groundwater and to ensure sufficient backfill for preventing exposure by erosion or subsidence at a later date. In addition to reducing pollution potential, pit clean-up efforts contribute to aesthetic improvement of a mine site.

Another disposal endeavor results from toxic waste materials exposed during active mining. Acidic overburden rock units, or impurities physically separated within the pit from the mineral, represent a potential source of water pollution and are detrimental to most plant growth. These and other toxic materials should be segregated during excavation, followed by pit burial. Deep burial is recommended to help reduce free air contact and improve chances for total inundation by ground water, which in turn eliminates free air contact. Exclusion of toxic materials from free air minimizes oxidation and the formation of pollutant by-products.

Cover Excavations

Surface mine closure should involve covering a portion or all of the remaining exposed pit area. Backfilling with spoil is a practice typical of most mining operations (such as coal mining and others), where large surface areas are affected in a relatively short span of time, and the volume of spoil is usually much greater than the volume of mineral extracted. Depending on the mining method, pollution potential and future land use, either complete or partial regrading should be performed in conjunction with backfill efforts. Complete regrading consists of reshaping spoil to cover the entire area exposed during mining. Referred to as contour regrading, this practice is a recommended procedure for preventing pollution from exposed highwalls and establishing aesthetic continuity between mined and natural topography.

In contrast to complete regrading, partial regrading usually results in a portion of the pit highwall remaining uncovered following abandonment. Nomenclature is varied for these regrading techniques with the general effect of producing either a terrace or swale configuration. Terrace regrading is particularly beneficial for reducing slope erosion in mining areas having extremely steep topography, and produces flat land suitable for grazing or minor agricultural development. Similar erosion protection can be accrued from swale regrading, and resultant depressions can serve as surface water collection basins, providing water for public or wildlife utilization.

Another partial regrading technique which is not recommended for use is leveling of spoil pile peaks. This procedure is aesthetically undesirable, and usually reduces land value for future use. In addition, the previously mentioned methods of partial regrading should not be employed in areas where water pollution will occur from exposed materials or where highwalls will present a safety hazard.

Several procedures are available as alternatives to backfilling and regrading for covering portions of mineral excavations. Characteristic of many open pit mines, these closure endeavors include highwall reduction and inundation. As indicated by its title, highwall reduction involves blasting or grading the upper highwall segment to reduce the effective height (this procedure is often combined with regrading operations). The loosened material provides minimal pit coverage and lessens safety hazards. While highwall reduction affords minimal pit coverage, inundation in many instances can provide a significant amount of coverage. This closure procedure usually entails allowing the pit to fill via ground water infiltration and direct precipitation. If water pollution will not present a problem, resultant impoundments may have a direct discharge, and may receive recharge from surface flows. Potential benefits derived from creating pit impoundments include: inundation of pollutant materials; minimizing highwall heights; and future use as a recreational facility.

Surface Preparation

Concurrent and following the above mine closure procedures, the affected land surface should be prepared to minimize pollution and improve post-mining aesthetics. Surface preparation techniques can be grouped into one of two categories with overlapping functions: 1) Water Infiltration Control; and 2) Erosion Control. The first category involves measures directed toward minimizing infiltration of surface waters and thus preventing contact between water and buried toxic materials. Erosion control procedures are primarily aimed at reducing unsightly gullying and possible stream siltation caused by uncontrolled surface runoff. Individual surface preparation procedures are listed below for each category.

1. Water Infiltration Control

   - Diversion Ditches - trenches should be constructed upslope from mined areas to divert runoff;

- Soil Sealants - impermeable materials such as clay, plastic or latex can be placed over regraded spoil to prevent infiltration;

- Underdrains - sub-surface channels can be constructed to facilitate rapid removal of near surface infiltration.

2. Erosion Control

   - Diversion Ditches - these should be employed as indicated for infiltration control;

   - Surface Scarification - a series of closely spaced ridges constructed roughly parallel to contour lines can effectively limit erosion by reducing water velocity;

   - Terracing - a series of terraces can be cut into steep embankments to intermittently reduce water velocity on steep slopes;

   - Mulching - this procedure should be used as a temporary measure to control erosion prior to implementing other methods and to protect seeded areas (straw and wood fiber mulches are relatively inexpensive and are effective);

   - Topsoil Replacement - used in conjunction with revegetation, topsoil replacement helps establish plant growth;

   - Revegetation - establishing a vegetative surface cover should be universally used to control erosion (plant species selection should consider a stable ecosystem and future land uses);

   - Rip-Rap - this erosion control method should only be considered as an alternative to revegetation in arid regions or on extremely steep slopes.

Special Cases

Further mine closure efforts in the immediate pit area are required when mining operations intercept abandoned underground mine workings, producing a direct pollutant discharge. Coal mines are the major source of this problem, which may result from exposing underground mine pools by auger mining, stripping into entries or creating fracture flow paths. For these acidic discharges, two general options are available: 1) plug the discharge; or 2) neutralize the drainage.

Plugging the discharge should be a primary consideration from both an environmental and an economic point of view. The basic principle entails blocking all exit ways for underground discharge. Various types of seals can be effective under given physical conditions, including the potential hydraulic head build-up. Clay liners can prove particularly useful for sealing long lengths of exposed underground mine workings.

Neutralization of acid discharges can in some instances be effected within spoil backfill. This procedure involves regrading with alkaline material (limestone, fly-ash, etc.) and installation of a slurry trench to cause inundation of alkaline backfill. Although alkaline regrading and slurry trench installation are only in the initial stages of demonstration the procedure holds great potential for future use.

As a final measure, polluted mine discharge should be collected and treated. Treatment technology is well documented, including the usually high construction costs and continued operating expenses. Extreme precautions should be taken during active mining to prevent breaching underground mines.

Dredging Operations

A unique method of surface mining, dredging requires slightly different closure considerations from those defined in the preceding sections. Since most mineral and refuse excavation is from below water surfaces, regrading and revegetation are not necessary within pit limits. The primary closure procedures entail disposal or reclamation of waste material.

Initial endeavors should attempt to replace (backfill) refuse below water level and restore normal flow channels. However, care should be taken during disposal to prevent pollution as a result of siltation or inserting concentrated toxic wastes. The next closure procedure should entail regrading and revegetation of all remaining refuse and disturbed surface area above water level.

Dredging operations are not common and mine closure procedures have not been precisely documented. Therefore, each active mine should be treated as an individual mine closure case with careful consideration for the post-mining environment.

UNDERGROUND MINE CLOSURE PROCEDURES

Closure procedures for abandoning underground mines are discussed within this section. Two general categories are delineated for active mine closure methods: techniques that are directly applicable to the underground mine environment; and methods available for implementation at the surface and extremities of mine development. For those mining operations employing one of the deep mining techniques previously mentioned, many of the following closure procedures should be executed upon termination of mineral extraction processes.

Procedures Within Mine Workings

The physical disposition of underground mine workings requires diligent thought concerning final closure operations. Insufficient consideration and planning can often lead to post-abandonment environmental problems such as pollution discharge, disruption of public ground water supplies and surface damage from subsidence.

Primary closure procedures involve the void created by removal of mineral and waste materials. Leaving the void in the form produced by normal mining activities is the simplest closure technique, and is acceptable for mines developed in stable rock or having sufficient pillars to provide permanent roof support. However, the potential consequences of subsidence or water pollution should be fully understood prior to abandonment.

Several other closure procedures are available to alter the mine void including: pillar extraction; backfilling; and mine flooding. Pillar extraction consists of mining a portion or all of the mineral blocks remaining as the primary roof support system. From an economic point of view, pillar "robbing" is desirable because the company realizes its highest profit per ton of coal mined. But pillar removal with subsequent roof collapse can be a major cause of environmental problems.

As the mine roof falls, fractures progressively develop upward into overlying strata. Depending on thickness of mineral extracted and depth of mining, surface subsidence will result with possible damage to buildings and other structures. In addition, these fractures can provide a direct avenue for surface and groundwater influx into mine workings. Aquifers used for public water supplies can be drained or lowered, and additional water will become contaminated if the mined mineral or refuse contains pyritic or other pollutant forming materials.

Backfilling mine voids with mine refuse, municipal wastes or other materials is a closure method which will help support the mine roof and reduce free oxygen necessary for most chemical pollutant formation. Solid stowing and hydraulic stowing are two techniques for filling mine voids. Such procedures should be evaluated in mining areas extremely prone to subsidence.

While mine flooding usually occurs by natural infiltration processes, it is a closure procedure in the sense that mine development and surface abandonment procedures can be planned to facilitate inundation. Mining down-dip from the mine portal will allow maximum flooding and is conducive to preventing gravity discharges. This method of mine development is recommended in conjunction with flooding where the mined area is a source of water pollution. Inundation will minimize contamination by limiting available oxygen for chemical reactions. Mine entry sealing is also recommended for possible polluted discharges. This procedure is discussed as a technique implemented from the surface.

In advance of final underground closure procedures, all equipment and supplies that are of value or can cause environmental problems, should be removed. With completion of underground abatement endeavors, final surface procedures should be initiated.

Procedures at the Mine Extremities or Surface

In addition to the general procedures described under the Surface Mines section as applicable to all mining operations, two basic types of closure methods should be employed at or near the surface. These abandonment operations entail either sealing mine entries and outcrop areas, or constructing devices to control water infiltration into mine workings.

As mentioned above, mine seals can be installed in association with planned mine flooding. However, many existing active mines were developed without consideration for inundation and sealing. In some instances partial inundation and mine sealing can be effected. Mine entry seals are classified into three general types: 1) air seals; 2) dry seals; and 3) hydraulic seals.

Air-sealing consists of closing all mine openings except for one or two at lower elevations. Here a wet seal with an air-trap is installed to prevent air flow into the mine while allowing for normal water discharge from the abandoned mine. This closure procedure is not recommended as an effective method for reducing acid formation.

Installation of dry seals should be performed to close mines developed in a down-dip direction. The procedure involves placing a filler (concrete blocks, clay, etc.) into mine entries to prevent access and reduce air circulation. Dry seals are recommended for mines where little or no hydrostatic pressure will occur on the seal.

Hydraulic sealing is a procedure performed to close all mine entries and allow mine flooding. With this type of seal, hydrostatic pressures will be generated and should be pre-determined to ensure sufficient seal strength for preventing pressure blow-outs. An effective hydraulic seal should also be grouted properly to prevent water seepage.

Although mine entries are usually the major avenue for water discharge, seepage may occur via fractures along the mineral outcrop. Grout curtains or clay liners should be installed if the seepage is polluted. Maintaining sufficient crop barriers during active mining will usually prevent this drainage.

Under the general category of closure procedures to minimize water infiltration, most techniques require detailed information concerning specific hydrogeologic parameters. Prior to implementing these procedures cost benefits should be determined. At individual sites where water supplies are being drained or polluted via infiltration into mine workings, the following closure procedures should be considered:

- Regrade and revegetate overlying surface mines;
- Fill or seal subsidence areas;
- Grout permeable stream channels or divert water flow around permeable zones (rechannel or flume);
- Apply surface sealants in permeable areas or over the entire mine;
- Plug or seal all boreholes;
- Install a well dewatering system (pumping or gravity drainage) to drain aquifers above the mine.

Since many of these closure procedures have limited use or are still in development stages, enforced application is not recommended. But, with specific problems and further research and development, infiltration control may become a standard procedure for implementation both during and following active mining operations.

Again, mine drainage treatment should be employed only as a last alternative for controlling polluted mine discharge waters. All the disadvantages of treatment that were delineated within surface mine discussions apply to underground mines. In fact, the problem is greater due to large volumes of drainage frequently realized from underground workings. The numerous alternatives should be explored before establishing permanent treatment facilities.

SECTION II

THE MANUAL

CONTENTS
SECTION II

Page

CHAPTER 1 - DEVELOPMENT OF STATEWIDE PROGRAMS 1-1

ESSENTIAL PROGRAMMING ELEMENTS 1-3
    Communication, Coordination and Integration 1-3
    Fiscal Resources. 1-7
    Established Authority 1-9
    Effective Program Planning and Management 1-9
    Well Trained and Experienced Leadership 1-10
CREATING ADMINISTRATIVE AUTHORITIES - ORGANIZATIONAL STRUCTURE AND FORMAT 1-10
    Redefinition of Duties 1-11
    Department Reorganization to Create New Agency 1-13
    Interagency Coordinating Councils 1-17
    Special Boards or Commissions 1-20
ESTABLISHING PHILOSOPHICAL FRAMEWORK, JURISDICTIONAL AUTHORITY AND POLICY 1-24
    Defining Purposes 1-24
    Establishing Powers and Duties 1-26
    Establishing Policy - The Decision-making Process 1-27
    Developing Programs and Implementation Plans 1-30
    Program Implementation Approaches 1-34

CHAPTER 2 - LEGAL PROBLEMS AND AVENUES OF DEVELOPMENT 2-1

INTRODUCTION 2-3
DEFINITION OF LEGAL STATUS. 2-3
    Judicial Precedent 2-5
    Legislation 2-6
LEGAL PROBLEMS 2-23
    Reclamation by Current Landowner 2-25
        Use of Existing Nuisance Laws 2-25
            Common Laws 2-25
            Statutory Schemes 2-27
            Water Pollution Control Laws 2-29
        Enactment of an Environmental Code 2-32
        Incentive for Reaffecting Orphaned Lands 2-33
        Summary 2-35

Reclamation by Mining Companies 2-36
Reclamation by the State 2-38
Privately Owned Land. 2-38
Publicly Owned Land 2-40
MODEL LEGISLATIVE APPROACH 2-42

CHAPTER 3 - PROGRAM FUNDING POSSIBILITIES 3-1

POSSIBLE FUNDING SOURCES 3-3
Federal 3-3
State. 3-4
Local 3-5
Private 3-5
FUNDING AGENCIES AND PROGRAMS 3-6
Appalachian Regional Commission 3-6
Department of Agruculture, Agricultural Stabilization and Conservation Service 3-11
Department of Agriculture, Farmers Home Administration 3-12
Department of Agriculture, Forest Service 3-18
Department of Agriculture, Soil Conservation Service 3-19
Department of Commerce, Economic Development Administration 3-22
Department of the Interior, Bureau of Mines 3-24
Department of the Interior, Bureau of Outdoor Recreation 3-25
Department of the Interior, Bureau of Sport Fisheries and Wildlife 3-27
Environmental Protection Agency, Office of Research and Development 3-28
Environmental Protection Agency, Office of Water and Hazardous Materials 3-30
Water Resources Council 3-31
AVENUES FOR TECHNICAL ASSISTANCE 3-32
Department of Agriculture, Forest Service 3-32
Department of Defense. Army Corps of Engineers 3-33
Department of Interior, Geological Survey 3-34
Department of Interior, Bureau of Land Management . . . 3-34
Department of Interior, National Park Service 3-34
Department of Interior, Bureau of Reclamation 3-34
Tennessee Valley Authority 3-35

CHAPTER 4 - TECHNICAL APPROACH 4-1

DEVELOPMENT OF BASE MAPPING 4-4
WATERSHED DEFINITION 4-9
WATER QUALITY SURVEY 4-12
- Assess Existing Data 4-13
- Establish Sampling Program 4-14
- Determine Stream Survey Parameters 4-15
  - Chemical Parameter Options 4-15
  - Physical Measurement Options 4-16
  - Biological Parameter Options 4-17
  - Sampling Frequency Options 4-18
  - Sample Location Options 4-18
- Typical Stream Survey Program 4-19

SOCIO-ECONOMIC SURVEY 4-22
- Human Resources and Economic Needs 4-25
- Current Land Uses and Values 4-26
- Development Demand 4-26
- Aesthetics 4-27

MINED LANDS INVENTORY 4-28
- Aerial Photography 4-29
- Photo Interpretation. 4-34
- Terrestrial Survey 4-39
- Land Ownership 4-42

RECLAMATION COST DEVELOPMENT 4-43
- Surface Mine Costs 4-44
- Underground Mine Costs 4-47
  - Extensive Background Information 4-48
  - Limited or General Background Information 4-53

COST EFFECTIVENESS 4-55
PRIORITIES 4-56
FINAL PHOTO AND MAP PRESENTATION 4-58

CHAPTER 5 - IMPLEMENTATION 5-1

TASK 1 - GATHER, MAP AND EVALUATE EXISTING DATA 5-4
- Water Quality Data 5-4
- Geology and Soils 5-5
- Mining 5-6
- Ecology 5-6
- Socio-Economic Conditions. 5-7

TASK 2 - ESTABLISH RECONNAISSANCE PROGRAM 5-7
TASK 3 - GATHER FIELD DATA 5-8
TASK 4 - INTENSIFY STUDY ON REDUCED SCOPE AREAS 5-9
TASK 5 - DETERMINE RELATIVE MINE DRAINAGE CONTRIBUTIONS (ACTIVE VS. INACTIVE) 5-9
TASK 6 - IDENTIFY DATA GAPS. 5-10
TASK 7 - DETERMINE RECLAMATION AND ABATEMENT FEASIBILITY 5-10
TASK 8 - ASSESS FUTURE MINING POTENTIAL. 5-12
TASK 9 - COMPUTE COST AND COST EFFECTIVENESS 5-12
TASK 10 - ESTABLISH PRIORITIES 5-13
TASK 11 - DEVELOP QUICK START PROJECTS 5-14
TASK 12 - FINALIZE MAPPING 5-14
TASK 13 - PREPARE FINAL REPORT 5-25
TASK 14 - POST RECLAMATION MONITORING AND ASSESSMENT 5-25

CHAPTER 6 - SECONDARY USE OF LAND INVENTORY DATA 6-1

LIST OF TABLES
SECTION II

Table		Page
1-1	Layers of Government Agencies Involved in Mined Lands Reclamation and Abatement Projects	1- 6
1-2	Internal Implementation Obstacles and Alternative Solutions	1-35
1-3	External Implementation Obstacles and Alternative Solutions	1-36
2-1	Synopsis of Laws Relative to Statewide Pollution Abatement	2- 7
2-2	Legal Bibliography	2-44
3-1	U. S. Bureau of Mines Liaison Program Officers, February 1, 1973	3-37
3-2	State Liaison Officers to the Bureau of Outdoor Recreation, March, 1973	3-45
4-1	Socio-Economic Ranking System	4-24
4-2	Number of Cloudless (10% or Less Cover) Days Per Month for Selected States	4-31
4-3	Typical Surface Mine Classification System	4-38
4-4	Segregation of Underground and Surface Mine Pollution Loads	4-50
6-1	Secondary Uses of Inventory Data	6- 4
6-2	Structure - Environmental Protection Agency	6-10
6-3	Structure - Department of the Interior	6-11
6-4	Secondary Uses of Inventory Data	6-12
6-5	Structure - Energy Research and Development Administration	6-15
6-6	Conversion Table	6-16

LIST OF FIGURES
SECTION II

Figure		Page
1-1	Organization Chart - Department of Environmental Resources, Division of Reclamation, Mine Pollution Abatement and Reclamation Section	1-15
1-2	Organization Chart - Interagency Cooperation	1-19
1-3	Organization Chart - Special Board or Commission	1-23
1-4	Rational Decision Process	1-29
4-1	Illustration of Base Map	4- 6
4-2	Illustration of Major Streams	4- 7
4-3	Illustration of Major River Basins and Watershed Boundaries Within Area Underlain by Mineral Bearing Deposits	4-61
4-4	Illustration of Base Map	4-63
4-5	Illustration of Major Streams	4-65
4-6	Illustration of Figures 4-4 and 4-5 Superimposed	4-67
4-7	Illustration of Major Basin, Watershed, and USGS 7.5 Minute Quadrangle Boundaries and Names	4-69
4-8	Illustration of Figures 4-4, 4-5, and 4-7 Superimposed	4-71
4-9	Illustration of Sampling and Flow Measuring Stations	4-75
4-10	Illustration of Figures 4-4, 4-5, 4-7, and 4-9 Superimposed	4-77
4-11	Illustration of Hot Areas and Severely Polluted Stream Within Cold Area	4-79
4-12	Illustration of Marginal Areas and Marginally Polluted Stream Within Cold Area	4-81
4-13	Illustration of Figures 4-4, 4-5, 4-7, 4-9, 4-11, and 4-12 Superimposed	4-85
4-14	Illustration of Surface Mined Areas	4-87
4-15	Illustration of Underground Mine Areas	4-89
4-16	Illustration of Figures 4-4, 4-5, 4-7, 4-14, and 4-15 Superimposed	4-91
4-17	Illustration of Composite Map	4-93
4-18	Illustration of 7.5 Minute USGS Quadrangle	4-95
4-19	Illustration of Aerial Photography	4-97

4-20 Illustration of Overlay Depicting Mine Features and Watershed Boundaries 4-99
4-21 Illustration of Composite Aerial Photography and Mine Features 4-101
4-22 Illustration of Feasible Method of Updating Mining (First Up-date) 4-105
4-23 Illustration of Feasible Method of Up-dating Mining (Second Up-date) 4-107

5-1 Successive Resolution of Study Areas 5-16
5-2 Illustration of Composite Map 5-17
5-3 Watershed Feasibility Study Final Index Map - Stage II Effort 5-19
5-4 Watershed Feasibility Study Abatement Area Location and Geology Map for Underground Mines - Stage III Effort 5-21
5-5 Watershed Feasibility Study Abatement Area Mine Development Drawing for Surface Mines - Stage III Effort 5-22
5-6 Watershed Feasibility Study Abatement Area Mine Development Drawing for Underground Mines - Stage III Effort 5-24

CHAPTER I

DEVELOPMENT OF STATEWIDE PROGRAMS

DEVELOPMENT OF STATEWIDE PROGRAMS

As increased federal funds become available for abatement and reclamation purposes, many states are expected to develop statewide "clean-up" programs. For most states, this will represent a first-time effort and it will be necessary to work through intricate details of organization, administration, management and finance. Toward these ends, this chapter will discuss the logistics of: establishing administrative entity, formulating program and policy, and executing program goals and objectives. Throughout the text an attempt will be made to identify those key elements essential for successful programs and the criteria which should be considered in program formulation.

The organization, direction, and implementation of abatement and reclamation programs is an immense and complex exercise involving a myriad of natural resource, economic, legal, and social conditions. Effective programs do not just "happen." They are the result of painstaking planning and meticulous attention to details of administration and management.

ESSENTIAL PROGRAMMING ELEMENTS

During the course of this study an effort was made to identify those factors which significantly increase the net effectiveness and efficiency of mined lands pollution abatement and reclamation programs. The rationale for this approach was that knowledge of obstacles and opportunities within existing state programs would lend insight into organizational, administrative, and management criteria which should be evaluated when establishing new ones. Existing state programs which were reviewed during the period of this study included: Illinois, Kentucky, Maryland, Ohio, Pennsylvania, and Virginia.

Communication, Coordination and Integration

Communication, coordination and program integration amon groups and persons concerned with abatement and reclamation ac-

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tivities are vital components of successful programs. Programs must be comprehensive in scope. They must address the issues of not only natural environments, but social, economic and political ones as well. As such many professionals from divergent backgrounds, occupations and viewpoints need to collaborate. Coordination of activities and programs among the following groups is paramount in order to maximize program effectiveness.

1. Legislative, Judicial and Executive Branches of Government - The legislative, judicial and executive branches of government assume very distinct but interrelated and interdependent roles in program conceptualization, organization, administration and implementation. Legislative coordination is essential in that State General Assemblies act to empower executive departments with administrative and jurisdictional authority, particularly in the realms of:

    a. appropriation of state funds for annual operating budgets and matching state shares for federal funds
    b. expenditure, and use of public funds on public and private lands, acquisition of lands for land reclamation projects
    c. defining primary administrative group responsible for directing and uniting state resources toward defined goals and objectives

    Executive departments of state government such as environmental protection, natural resources, conservation, or mines and minerals are typically charged with the responsibility for actual implementation of environmental improvement programs developed by the legislative process. In these instances, the executive departments also assume roles of feedback and advisement. It is not uncommon for executive departments to recommend changes in legislation to expedite implementation of abatement and reclamation programs.

    Judicial support of programs effectively eliminates or reduces the legal obstacles which may prevent program implementation. As programs are being formulated a review of pertinent decisions in the realms of use of public funds, land acquisition and civil liberties of landowners must be conducted.

In situations such as in Appalachia where a geographic area is characterized by a whole host of problems of which inactive mined lands is but one aspect, collaboration and coordination of several federal, state and local government agencies is essential - particularly if one of the pollution abatement program goals is to improve the economic conditions in a region. Table 1-1 displays the many layers of authority and different governmental agencies having roles and responsibilities in inactive mined lands programs and projects.

The decade of the 1970's has been characterized by two contradictory trends. One is to reduce the number of departments and divisions in an effort to consolidate similar type functions and activities. The basic objective being to reduce or eliminate duplication, interagency competition and inefficiency. (23) The other is to establish new state agencies (example: State Environmental Protection Agencies) to undertake programs and render services previously not available.

The proliferation of environmental legislation during the 70's has had great impact in altering long-established state departments' duties and has mushroomed the number of new agencies who are still in the process of establishing their roles. The net result has often been a greater fragmentation of responsibility in the field of mined lands pollution abatement and reclamation.

2. Research Organizations - Whether they are private foundations, academic, or industrial, research organizations serve as the genesis of new technological advances. Unfortunately these organizations frequently operate in a vacuum with

Table 1-1
LAYERS OF GOVERNMENT AGENCIES INVOLVED IN MINED LANDS RECLAMATION AND ABATEMENT PROJECTS

14	Department of Interior - Bureau of Mines
13	U. S. Environmental Protection Agency
12	Department of Defense - Army Corps of Engineers
11	Department of Health, Education and Welfare
10	Appalachian Regional Commission
9	State Department of Natural Resources
8	State Environmental Protection Agency
7	State Department of Economic and Community Development
6	Regional Planning District
5	Local Planning Council
4	Soil Conservation District
3	County Commissioners
2	Township Trustees
1	Landowners

the potential user not being aware of the new techniques and the researcher lacking field orientation for further refinement of his experimental designs. Acid mine drainage research is a prime example of this predicament.

3. Mining Industry - Recent passage of more stringent mining laws and water pollution control measures has often strained working relations between government and industry. Many mining companies are very reluctant to share data and information for fear that it will ultimately be used against them. At the same time concerned government officials are at a loss to base policy decisions and new rules and regulations on accurate data. Clearly, both government and industry need to seek each other's advisement and proceed toward solving common problems.

4. Special Interest Groups - A working relationship with special interest groups such as trade organizations, mining and reclamation associations, and environmental groups is often necessary in order to:

   a. stimulate public and private support;
   b. obtain otherwise unavailable data and information;
   c. assist in exerting influence and pressure on policy makers;
   d. provide long-term vitality to a program; public citizens fluctuate in their input; special interests do not; they maintain long-term relationships.

Fiscal Resources

As might be expected, availability of fiscal resources is a major component of viable abatement and reclamation programs. Although preliminary program organization and planning can be accomplished with minimum funds through interagency cooperation and use of in-kind services, the ultimate field work requires large sums of money over an extended period.

Federal funds which are available are often very limited in scope and require tremendous accounting procedures, which states with minimal personnel and funds cannot affort. "It takes state money to get federal money" often seems to be the rule.

Frequently changing federal funding guidelines and procedures often serve to limit state programs. Changes in program emphasis restrict state programs to very short-term planning. The result is that state agencies find themselves constantly trying to change step in midstride to keep up with changing federal requirements.(27)

State programs which have enjoyed the greatest measure of success in keeping programs and projects funded are those which have established specific state funds for major aspects of a mined lands program. The states that have comprehensive funding for their programs include Kentucky, Ohio, Maryland and Pennsylvania. The sources and amounts of their program funds are discussed in Appendix B.

When special state funds are established, their administration and management should be within the same agency that will be using them. Well defined funding avenues reduce administrative bookkeeping chores, competition from other "pet" projects, and time, and increase budgeting capability. Step by step procedures within a single accounting system allow for orderly transition of funds as the state program matures and becomes more sophisticated.

Other fiscal limitations include constitutional definitions of how state funds may be acquired and expended. Most states are required to maintain balanced annual budgets.

State program funding needs typically are categorized as follows:

1. In-house Operations

    a. staff salaries and expenses
    b. office materials
    c. equipment
    d. contracted services

2. Special Planning & Inventory Studies
3. Project Feasibility Studies & Reports
4. Engineering and Design Documents
5. Contracted Construction Work
6. Monitoring and Evaluation Studies

Established Authority

Problems inherent to program coordination and implementation are reduced or eliminated when there is just one dominant administrative group.

Lack of clear-cut (established) authority, both formal and informal, produces interagency jealousies, undermining of projects, and fragmentation of effort. To be effective in reducing legal problems, administering groups need enforcement, sanctioning, and condemnation powers.

Budgeting problems often arise when several agencies having responsibility for different aspects of mined lands programs must compete for departmental funds and the director's favor. Coordinating mechanisms and cooperative attitudes are difficult if not impossible to achieve under conditions of fragmented authority.

Effective Program Planning and Management

As mentioned earlier in this chapter, effective programs do not just happen. They require long range planning -- not planning for planning sake, but a methodical step by step approach which considers many alternative means for accomplishing ends. The development of concise goals and objectives is an essential first step of program formulation. Goals and objectives which identify priorities and tasks lend direction and credibility to programs. Well defined and realistic goals and objectives reduce problems of communication, coordination, funding, and role definition.

In order to accomplish any significant results, an abatement and reclamation program must be task oriented within time and fiscal constraints that represent a true picture of the actual natural, economic, political and social conditions. Organization and direction are also key prerequisites for successful programs. In order to gain public and legislative acceptance and support, an administering agency must be able to define its purposes, duties, goals, and objectives in as concrete terms as possible -- when possible within physical units of output and unit operations.

Well Trained and Experienced Leadership

The measure of success afforded a program is directly related to the abilities and personalities of the people who function in it. Strong and aggressive leadership is essential within an agency in order for it to secure favorable support of agency activities, and in maintaining the morale of employees and their commitment to program goals. Unfortunately, because much decision-making is conducted literally by "committee," the emergence of leaders is often difficult.

Well-trained and experienced staff who are familiar with field conditions and practical realities of initiating field activities greatly increase an agency's problem solving capacity. The depth of motivation and zeal for their work also enhances staff creativity in solving novel problems while a sophistication in working through red tape reduces lag time in program implementation.

CREATING ADMINISTRATIVE AUTHORITIES' ORGANIZATIONAL STRUCTURES AND FORMATS

Within recent years as administrative agencies have expanded their roles and responsibilities with respect to environmental measures, there has been a greater effort to increase effectiveness of their operations. This effort has been undertaken in three ways:

1. To reorganize the departments so that administrative authority is shifted to upper levels of the organizational hierarchy to permit more inclusive

interests be taken into account.

2. To resort increasingly to quantitative data and empirical methods of analysis for policy decision and determining program direction and action.

3. To modify traditional administrative arrangements in order to encourage vitality and creativity in the bureaucratic system. (23)

Since most environmental legislation during the 1970's required immediate enforcement or administrative action to commence policy implementation, many states were forced to create or designate administrative authorities almost overnight. The manner in which states organized authorities to administer abatement and reclamation programs was often influenced by the nature and extent of allied new environmental programs and legislation. It is not uncommon for various departments to compete for leadership roles which contribute to internal strife. Abatement and reclamation activities, as a result, are often administered by more than one agency, decreasing total program unity. A discussion of approaches for organizing administrative authorities for abatement and reclamation programs follows.

Redefinition of Duties

One means of quickly establishing an administrative authority is to simply redefine and expand the duties of an existing agency (at a divisional level) already organized with a state's department of natural resources or conservation. Feasible choices could include divisions of mines, reclamation, minerals, planning or research.

Under this approach there are no overt changes in staff, policy, or programming. The program and its projects would not be depicted in separate organizational charts. Abatement and reclamation projects are merely absorbed into existing programming with personnel in-house possibly being assigned on a part-time basis.

Redefinition of the duties of an existing agency typically are advantageous under the following circumstances:

1. The magnitude of environmental problems associated with inactive mined lands is not great.

2. There are minimal funds available for a program.

3. Public clamor does not necessitate immediate action.

4. Program does not have high priority.

Key decision criteria before selection of an absorbing agency include:

1. Prior experience with mining and mining related problems.

2. Size, training and experience of staff.

3. Status and extent of other on-going programs which may either hinder or aid new programs.

4. Fiscal resources available to support new programs.

5. Equipment available to support new programs.

6. Ability to coordinate, and integrate new programs with existing ones.

7. Political clout of agency.

8. Favorable working relations and support of special interest groups.

9. Administrative and management skills of executives.

10. General tenor and attitudes of subordinates toward their leaders and the program.

Staffing requirements for the low profile approach just described is minimal. Typically an administrative assistant handles daily administrative chores and assigns technical personnel to different aspects of the program. The technical staff utilized often involves individuals with training in geology, soils, hydrology, forestry, material resources planning and civil or mining engineering.

Advantages of using an existing agency include:

1. Capitalizing on the experience and knowledge of employees who are familiar with abatement and reclamation problems.
2. Ability to incorporate a new program with minimal resources into other programs which compliment it.

Disadvantages (which may outweigh the advantages):

1. New approaches (creativity) may be hindered by traditional attitudes, policies, and procedures.
2. Program may be constrained by higher priority of concurrent programs.
3. Work schedules may be so heavy that employees never get time to devote to the new program.

Departmental Reorganization to Create New Agency

Reorganization of state departments of natural resources increasingly has occurred with enactment of environmental legislation. Reorganization as defined here entails establishing a formal administrative agency at a divisional or sectional level within a department. Reorganization is characterized by:

1. Changing the organizational structure and hierarchy of command.
2. Transferring personnel and changing job descriptions.
3. Changing program priorities.
4. Altering policy.

The new agency formed as a result of reorganization typically:

1. Functions within annual departmental budgets and has its own budget.

2. Has a separate full time staff.

3. Has its own established policies and procedures.

4. Uses comprehensive delegated authority.

5. In-kind service use is limited and consultants are contracted for extensive studies.

Creation of a new agency through reorganization is advantageous when a state has:

1. Extensive environmental damage from inactive mined areas.

2. Adequate funds to support the activities of a new agency.

3. Established the program as a long-term commitment.

4. Public constituency demanding forthright action.

5. No existing administrative agency which can successfully absorb the program at the magnitude of effort required.

As indicated in Figure 1-1, the staffing pattern for a mine pollution abatement and reclamation section is much more comprehensive than the previous example. In Figure 1-1 a single administrator is responsible for both the abatement and reclamation aspects of the program. Hopefully, under such an arrangement, coordination and integration of programming would be increased.

The advantages of utilizing the new agency approach include:

1. New agency is not constrained by traditional

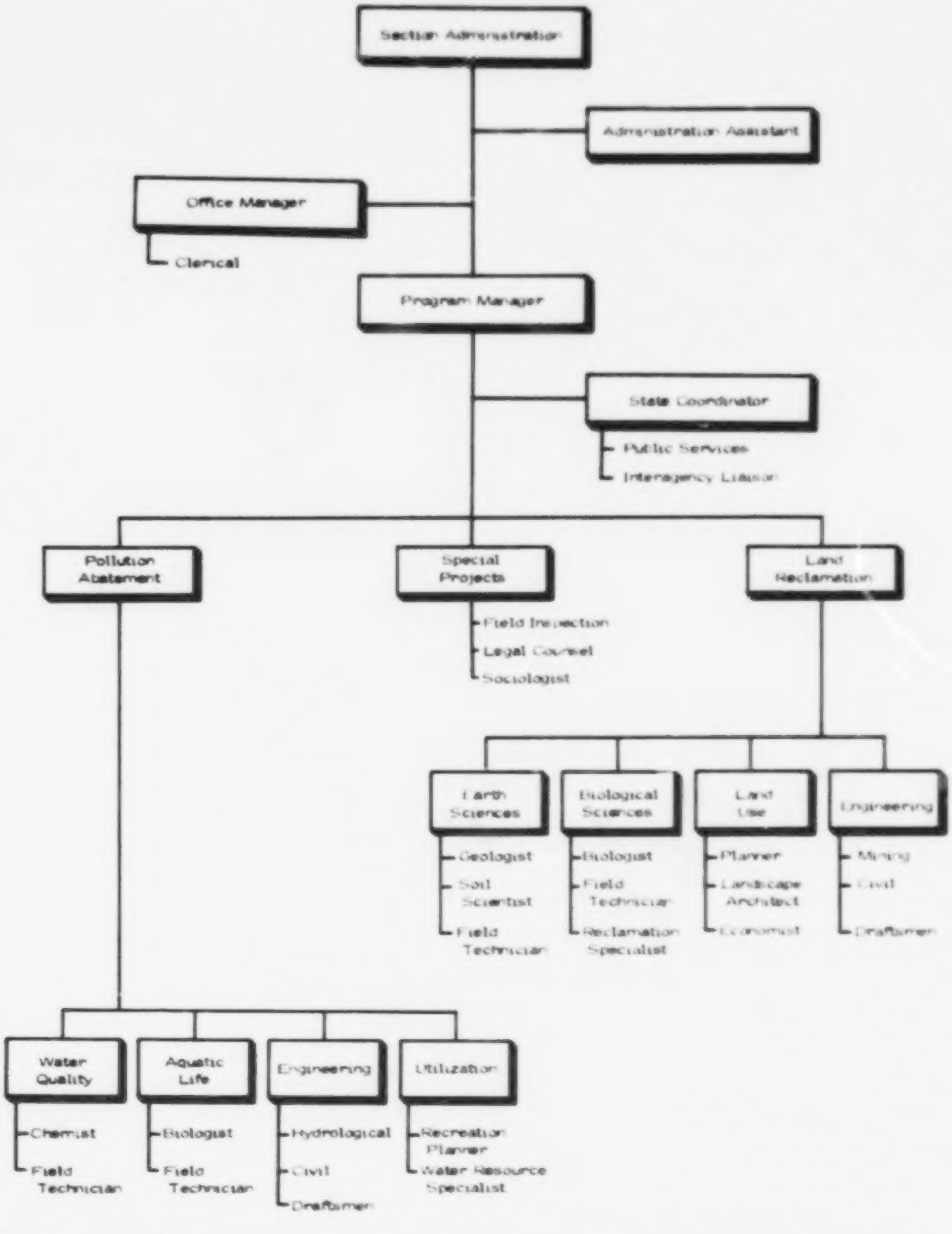

Figure 1-1. Organization chart.- Department of Environmental Resources, Division of Reclamation, Mine Pollution Abatement and Reclamation Section.

roles or old policy and procedures.

2. New program assumes a high priority position and all resources are focused upon achieving program goals.
3. Public visibility is increased.
4. New staff and duties add vitality to entire program.
5. Communication and coordination mechanisms are increased.
6. Can make long-range plans.
7. Have established powers and authority.
8. Reduces administrative management problem--direct control of immediate fiscal and personnel resources; one set of rules and procedures.

Disadvantages of this approach include:

1. New agency may have to compete with older more established agencies for departmental funds and dominance in role and responsibilities.
2. When reorganization occurs in middle of the fiscal year, there may be no departmental funds to secure new staff, equipment, and contract services.
3. New agency could become a melting pot for personnel misfits from other groups if new personnel is not added.
4. Lead time is long. It may take up to two years to secure departmental funds for staff equipment, etc. Recruitment and hiring of qualified staff is a tedious process.
5. A total in-house effort may result in a loss of working relationships with other groups.

6. Overall departmental policies, priorities and budgets may constrain program.

The states of Pennsylvania and Maryland have in-house full time staffs to administer their state programs. A description of these respective programs is located in Appendix A.

Interagency Coordinating Councils

Interagency coordinating councils represent an alternative means for establishing an administrative mechanism for initial conceptualization and development of an abatement and reclamation program. Coordinating councils are typically:

1. Organized within the executive branch and attempt to combine assets of each agency.
2. Composed of appointed members from various departments; both state and federal levels.
3. Formed in response to a recognized problem or issue for which one agency does not have blanket authority.
4. Have no actual implementation powers, except through use of in-kind services.

Coordinating councils are effective when a state:

1. Has extensive natural resources and environmental departments.
2. Does not have funds to support a comprehensive clean-up effort.
3. Is in the process of making initial plans for a program or desires to work on just one particular project.

Membership on coordinating councils is usually multidisciplinary and may include representatives from economic development, health, and education departments. Council membership may include both federal and state personnel. Length of membership is usually on a short term basis -- often terminating as soon as an issue is resolved or the purpose of the council is achieved. Figure 1-2 depicts the type of membership associated with a coordinating council approach.

In some instances, such as in Kentucky and Illinois, state abatement and reclamation programs have been initiated using an interagency approach which utilized the resources of state universities. Further descriptions of these programs are located in Appendix A.

Advantages of interagency coordination include:

1. Opportunity for greater communication, coordination and integration of programs.

2. Reduction of duplication of effort among groups having common goals.

3. Membership usually involves key decision-making personnel from other groups.

4. Increases problem solving capacity and effectiveness by providing a comprehensive perspective to problems instead of isolated aspects.

Disadvantages involve:

1. Many different layers of authority in support group. If the coordinating council does not wield much influence - lack of subordinate cooperation within each support group could present major obstacles to accomplishing intended goals and objectives.

2. "Committee" decision-making of many groups. It may be difficult to obtain a majority consensus.

3. Increased administrative tasks and red tape -- particularly in matters of using in-kind services.

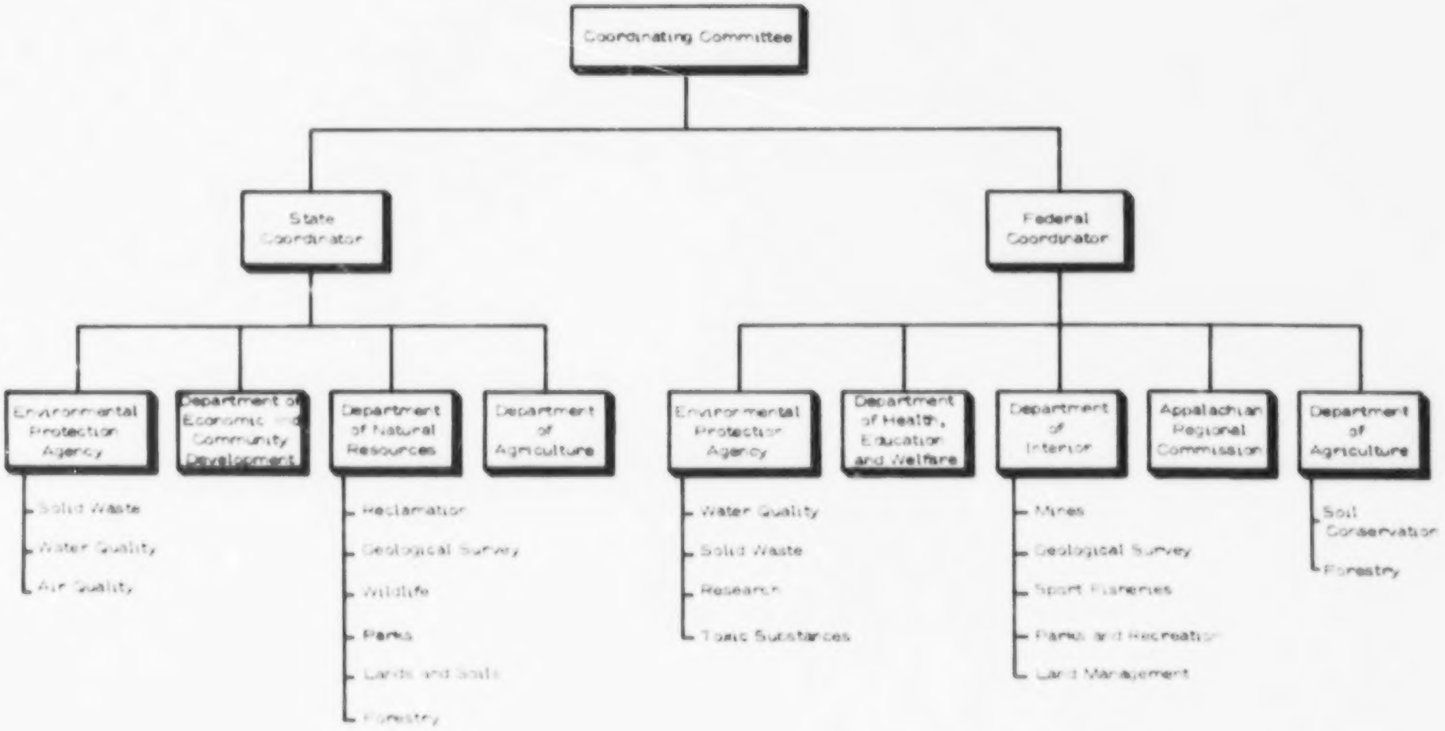

Figure 1-2. Organization chart - interagency cooperation.

4. Very limited or no implementing powers.

5. Participating agencies may have vested interests which supersede council goals.

6. Individuals having input on council may be so tied to daily chores of their jobs that they have limited time to devote to council. Hence, program may take a long time to develop.

Special Boards or Commissions

Special boards or commissions have become almost as common as bureaucratic organizations themselves. It is not unusual for boards created for short-term purposes to become literally permanent standing committees long after fulfilling their original mission.

Characteristics of special boards or commissions are:

1. Creation by legislative mandate or executive directive.

2. Membership is appointed by the governor or director of natural resources.

3. Term of membership is 2-4 years.

4. Membership is composed of legislators, private citizens, expert state personnel.

5. Usually function within strict fiscal and time constraints.

6. Are task oriented.

7. Duties usually involve conducting investigations and making recommendations.

8. May employ a staff and hire consultants to perform work.

9. Report findings on an annual or biennial basis.

The use of special boards or commissions is warranted when a state:

1. Is initially conceptualizing a statewide abatement and reclamation program.

2. Has no existing single state agency which can assume preliminary program planning role.

3. Has a limited data base from which to extrapolate information for program planning and policy formulation.

4. Has a public constituency demanding immediate action to correct environmental problems.

As mentioned earlier, board membership is typically composed of members of the state general assembly - both House and Senate. The legislative members are usually prominent leaders possessing much political influence and they may serve on appropriations, and/or natural resource committees. Legislative members may comprise up to one-third of the committee.

Their active participation and support of the committee is essential. There is no better lobbyist for a program or an administrative group than a legislator. Legislative favor is a vital ingredient to all aspects of mine drainage abatement and reclamation programs -- from beginning to end.

Expert state personnel also play a prominent role on special boards. Without their knowledge, experience and government skills, the resources of state departments would largely go untapped. Without the expertise and power of career officials most boards could never hope to achieve the results they desire. Influential state personnel usually have the capacity to mobilize sufficient resources within their respective departmental organizations to break down complex problems into smaller and hence more manageable tasks. One half of the board membership may be comprised of expert state personnel.

By widening the circle of those allowed to participate in program development and policy discussions, an open system such as a public board with a membership of private citizens allows input by knowledgeable individuals who would otherwise be excluded from the deliberative process. (51) Figure 1-3 depicts the associated organization charts for special boards or commissions.

Advantages of utilizing a special board or commission as an administrative authority include:

1. A board allows for a broader canvassing of alternatives and the emergence of majority and minority points of view.

2. Occupational requirements for appointment lend a formal "legal" blessing to the group in establishing credibility. This is essential in public, professional and political acceptance of board's findings and recommendations.

3. Frequent professional and social contact between legislative, executive and public constituency increases familiarity and respect.

4. Varied backgrounds of membership increases decision effectiveness.

Disadvantages:

1. Boards and commissions disperse rather than focus executive leadership and control.

2. Diversity of individuals and backgrounds could contribute to internal power battles between uncompromising viewpoints.

3. Responsiveness may be diminished due to difficulty in obtaining a consensus.

4. Boards often have no implementation powers.

5. Members' attendance may be erratic due to schedule conflicts with jobs, lack of payment for services, and lack of mandatory attendance.

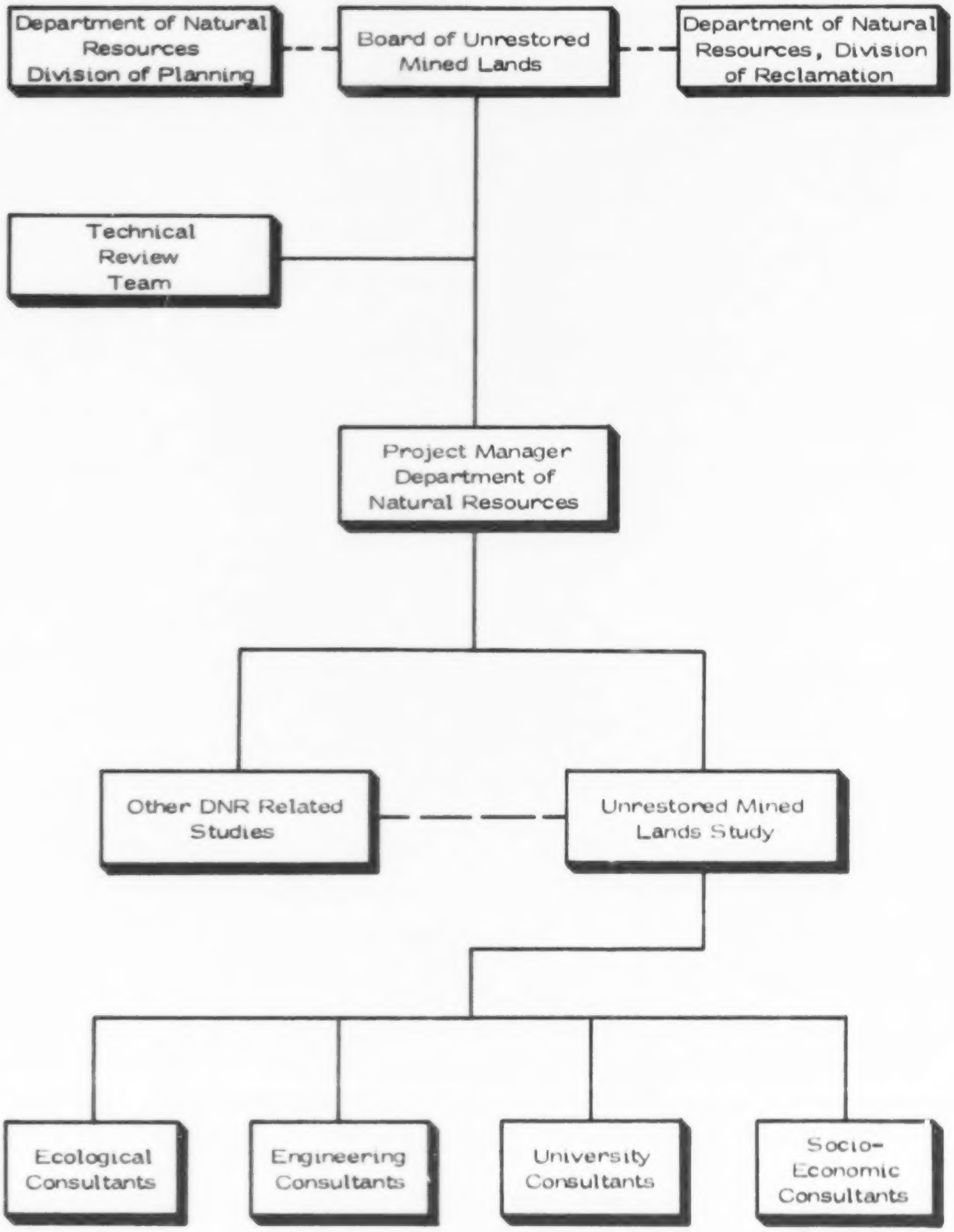
Department of Natural Resources Division of Planning
Board of Unrestored Mined Lands
Department of Natural Resources, Division of Reclamation
Technical Review Team
Project Manager Department of Natural Resources
Other DNR Related Studies
Unrestored Mined Lands Study
Ecological Consultants
Engineering Consultants
University Consultants
Socio-Economic Consultants

Figure 1-3. Organization chart-special board or commission.

6. Boards are often dependent upon third parties to actually carry out work assignments and tasks.

7. Board assumes primarily a passive role.

Special boards and commissions have been used in developing statewide abatement and reclamation programs in Ohio and Virginia. A description of the Ohio Board of Unreclaimed Strip Mined Lands and its program Land Reborn is located in Appendix B.

ESTABLISHING PHILOSOPHICAL FRAMEWORK, JURISDICTIONAL AUTHORITY AND POLICY

As the organizational structure of an administering authority is being developed, the purposes, duties and powers of the administering group must also be defined. Ultimately, it is the design of an agency's political system rather than its organizational structure which determines if programs ever become implemented. The effectiveness of a program - once defined - is limited by the quality of decision-making and magnitude of political and legal mechanisms available to convert those decisions into action.

Defining Purposes

Statements of purpose are usually included in the documents which establish the administering authority whether it be accomplished by:

1. Constitutional amendment.

2. Legislative act.

3. Changes in departmental rules and regulation by executive order.

4. Charter revision.

Basically a statement of purpose establishes the philosophical framework from which duties and powers, goals and objectives, roles and responsibilities, scope of work, and policy decision are generated.

Criteria to be considered in writing statements of purpose are:

1. What are the key issues that must be addressed by the administrative authority?

2. What are the purposes and functions of existing agencies within a department or other departments having input to the potential program?

3. The language of the statement of purpose should define long range roles, responsibility and results of the administrative authority's activities in as quantitative and qualitative terms as possible without severely limiting the flexibility of approach.

The following are examples of possible statement of purpose for administrative authorities. The first example is less definitive than the last and it is open to very broad interpretation. As demonstrated by the following examples, statements of purpose serve as the first vehicle for determining course of policy decision and program implementation.

Example A

The purpose of the Board of Unrestored Mined Lands is to restore those lands and waters within the state which are affected by past mining activities.

Example B

The purpose of the Inactive Mined Lands Commission is to organize and direct the abatement and reclamation of waters and lands polluted from past mining activities.

Example C

The purpose of the Unrestored Mined Lands Section shall be to formulate and implement a long-term plan and program for abatement and reclamation of polluted waters and lands affected by past mining activities to such ends that said waters and lands will be returned to productive use.

Establishing Powers and Duties

The formal powers and duties of an administrative agency serve as the fuel for forwarding the agency's activities. Legislatively delegated powers provide the best legal means for establishing an agency's role and activating its functions. The use of inferred powers should be avoided as much as possible because of broad subjective interpretation. Delegated powers established by legislative acts or executive order are less apt to be subjected to the judicial process for interpretation. To be effective, the administering authority for abatement and reclamation programs must include the powers of:

1. Advisement and recommendation.

2. Coordination.

3. Sanctioning.

4. Enforcement and implementation.

    a. litigation
    b. condemnation
    c. eminent domain
    d. civil penalty
    e. criminal penalty

When possible the language used in defining powers and duties should enumerate tasks that the agency is to pursue. The following are examples of types of powers and duties for an agency responsible for a state abatement and reclamation program.

The mine pollution abatement and reclamation section of the division of reclamation shall plan, administer, enforce, and implement a statewide abatement and reclamation program. In executing their duties the section shall:

1. Gather information, study and make recommendations concerning the number of acres, location, ownership, condition, environmental damage resulting from the condition, cost of acquiring and reclamation of the standards of the existing mining laws, possible future uses and value of lands and waters. (47)
2. Plan, develop and institute programs and policies for the abatement and reclamation of inactive mining sites.
3. Prepare and maintain surveys and inventories of the sources, causes and effects of mine drainage from inactive mining sites.
4. Assume responsibility for acquisition, supervision and maintenance of unreclaimed mined lands.
5. Adopt rules and regulations regarding
   a. post use of lands reclaimed with public funds
   b. bidding and contracting of work to be conducted on state abatement and reclamation projects.
6. Enforce by proper legal action the protection of lands and waters of the state from pollution by inactive mining sites.
7. Consult with and provide technical services to non-mining groups and individuals.
8. Publish and submit to the Governor and General Assembly, an annual report of agency activities.

Establishing Policy - The Decision-making Process

Policy formulation is the primary means of translating an agency's purposes, duties, and powers into actions. Examples of the types of issues decided by official policy include:

1. What role does the state assume in restoring lands and waters in the state degraded by past mining activities?

2. Will the state expend public funds on developing new and improved abatement and reclamation techniques or focus its resources upon utilizing only those approaches which have had high success in the past?

3. What aspect of the program will receive central focus -- water improvement, land reclamation, or reduction of air pollution?

The process in which policy is formed consists of decisions rendered by agency personnel -- from subordinates to middle level administrators to top administrative executives. The ultimate effectiveness of the agency and its programs is a reflection of the quality of the decisions made by all these persons.

Since abatement and reclamation programs encompass problems of natural systems, the decision process relies upon scientific data and the incorporation of objectivity into decision-making. Subjective factors such as political influences, funding availability, and personal bias of staff are also inherent to the decision process, but as an agency and its programs become more complex the subjective input may assume precedence over the objective input. Thus, it is incumbent for decision-making personnel to recognize the roles of both objective and subjective influences and attempt to keep them in perspective.

One means of accomplishing this goal is to use a rational decision process such as the one depicted in Figure 1-4. Basically the rational process is a matter of simply attempting to:

1. Identify the sources and types of objective and subjective influences both internal and external to the agency and its programs.

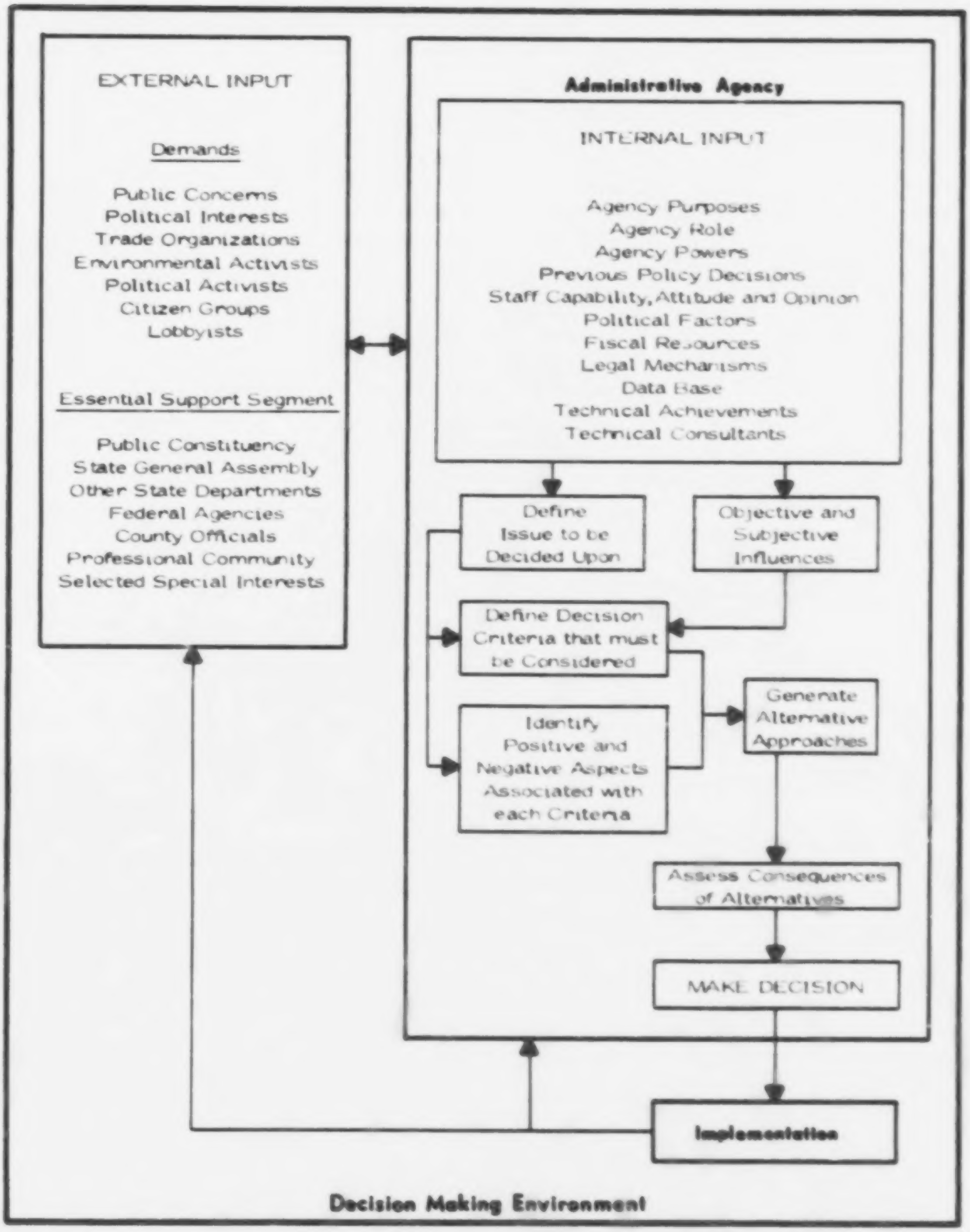

Figure 1-4. Rational decision process.

2. Anticipate the consequences of each possible decision.

3. Base decision on the alternative which will yield the most desirable outcome.(12)

In essence, the purpose of the rational decision process is to help prevent agency and program administrators from becoming lost in the maze of factors that must be considered, so they can make intelligent decisions.

Developing Programs and Implementation Plans

Successful programs are the result of well conceived plans. In state abatement and reclamation programs, planning is the methodical process by which a program is defined in terms of:

1. What are the problems? What is the nature, extent and impact of unreclaimed mined lands in the state?

2. What are the program goals and objectives? What does the state wish to achieve? Improvement of socio-economic conditions as well as environmental conditions?

3. What resources will be needed to achieve the program's goals and objectives and how much will the abatement and reclamation work cost?

4. How should the state's resources be organized so that the program's goals and objectives can be attained most efficiently and effectively?

5. Where should projects begin and what should be done?

6. What type of results can be expected? What is the anticipated outcome?

7. Did the program achieve what it was intended to do?

8. Why was the program a success or a failure?

9. What changes should be made in the program so it will be more successful?

Two of the most important aspects of program planning are establishing program goals and objectives and implementation strategies. Basic criteria which should be considered in developing goals and objectives include:

1. Relevancy to existing state environmental, economic, social, and political conditions.

2. Technical, economic, legal and political feasibility.

3. Congruity with other federal and state environmental programs, funding requirements, and legal mechanisms.

Examples of comprehensive program goals and objectives include:

I. Abatement of pollution from inactive mine sites

II. Restoration of lands and waters affected by pollution from abandoned or inactive mine sites to productive use including recreation, conservation, agricultural, residential and industrial utilization.

    A. Establishment of a long-range plan for mined land reclamation and mine drainage pollution abatement.

        1. Study and make recommendations concerning the number of acres, location, ownership, condition, environmental damages, cost of acquiring and reclaiming lands to a productive use, potential future uses and value of unreclaimed lands and streams and their affected areas.

        2. Creation of one administering authority which would assume the primary respon-

sibility for planning, organizing, directing and implementing reclamation and abatement program.

3. Develop an implementation strategy identifying long-range and short-term goals and objectives; major tasks, time frames, fiscal and personnel resources necessary to implement a program in an effective and efficient manner.

4. Establish a system for evaluating and selecting projects for field implementation.

5. Investigate, propose and establish alternative funding methods.

6. Monitor and evaluate results of overall program and individual projects.

B. Study, recommend and establish mechanisms for encouraging reclamation and abatement by non-governmental agencies -- including the mining industry, non-profit organizations and private citizens. The primary objective being abatement of pollution while still allowing recovery of a mineral resource; and alleviating the burden of expenditure of large sums of public funds on lands underlain by minerals which may be needed by future generations.

C. The investment of public funds on restoration projects which are economically viable, technologically feasible and environmentally sound.

D. Coordinate and integrate reclamation and abatement activities by federal, state and local governments. The primary objective being to bring all forces to bear in solving pollution problems.

III. To determine extent of mineral bearing areas in state.

IV. To determine extent of extraction and existing condition of environment affected by such extraction.

V. To determine socio-economic parameters which will act as constraints on future reclamation programs.

VI. To determine legal constraints on future reclamation programs.

VII. Develop proposals for improving environmental quality within the study boundaries in areas affected by mineral extraction and justified by socio-economic constraints and within scope of current and projected technology. Proposals shall be judged against the criteria:

A. Need to improve water quality

B. Future land use benefits to accrue from reclamation

C. Degree of economic stimulation

D. Cost

E. Water quality improvement benefits

F. Public visibility

G. Leverage: funding
political

H. Land ownership (public vs. private)

I. Long term vs. short term use input

J. Recreation activity enhancement

K. Early action vs. long term or complex projects (46)

VIII. Recommendations will be developed according to:

A. Feasibility study programs in priority groupings

B. Feasibility and proposals for early action projects

C. Legal changes necessary to allow or encourage reclamation per "A"

D. Criteria for engineering plans and specifications for reclamation plans

E. Need and criteria for monitoring results of reclamation projects (46)

Implementation is the process by which goals and objectives are translated into concrete and meaningful services. In this case, it is the improvement of water quality of polluted stream or the return of barren land to productive use. As might be expected, the more complex the problem, the greater the problem of implementation.

Just because program goals and objectives have been defined does not mean that they will be implemented or that the results achieved will approximate those expected. It cannot be assumed that policy or goals formulated at executive levels will be translated into specific actions at subordinate levels. Some of the common internal and external obstacles which may block effective program implementation are listed in Tables 1-2 and 1-3 with possible solutions.

Program Implementation Approaches

Two basic approaches by which programs may be implemented are:

1. Incremental and
2. Revolutionary

Table 1-2
INTERNAL IMPLEMENTATION OBSTACLES AND ALTERNATIVE SOLUTIONS

OBSTACLE	ALTERNATIVE SOLUTIONS
Personnel: Manpower Shortage; Lack of experience or expertise.	Hire new staff members; Transfer staff from other divisions or sections; Through in-kind services use skills of staff from other departments; Employ consultants; Use college students as part of an in-service training program; Volunteer assistance from qualified persons and groups.
Staff Communications: Confusion and misunderstanding of what is to be accomplished and how it is to be done.	Clarify and reduce goals and objectives to a level of simple language. Define and assign tasks to individual staff members -- set deadlines and define outputs. Then check up on regular intervals. Involve staff in decision-making by soliciting their views and evaluating their ideas. Review and analyze communication procedures, methods and systems. Develop explicit guidelines and procedural documents.
Subordinate Opposition	Discharge. Transfer to another division. Charge duties and responsibilities. Provide incentives for support by financial reward and upward mobility in position. Involve persons in program in a manner which will net them rewards greater than if they did not participate. Hire new staff. Employ consultants.
Capacity Problems: Critical time shortage; grossly inadequate funds; inadequate data; lack of equipment.	Reevaluate and design more realistic goals and objectives. Review and redefine anticipated results. Restructure implementation strategy and methods. Seek assistance from other resource and support groups.

Table 1-3
EXTERNAL IMPLEMENTATION OBSTACLES AND ALTERNATIVE SOLUTIONS

OBSTACLES	ALTERNATIVE SOLUTIONS
Lack of State Fiscal Resources	Use in-kind services of allied organizations and groups. Seek federal funds. Establish special state funds and revenues. Develop incentives for abatement and reclamation to be done by mining industry and private citizens. Revise and amend existing funding requirements.
Legal Problems -- Land Acquisition	Revise duties and powers of agency. Revise agency and department policy. Challenge judicial decisions. Alter methods of land acquisition by constitutional amendment. Change land acquisition requirements. Exhaust conventional methods of purchase, gift, lease, eminent domain, condemnation, property lien.
Lack of Political Support	Initiate a lobbying effort. Designate a liaison officer from the agency to work with general assembly. Hold briefings for legislators. Perform duties for legislators which will win their favor and support. Incorporate legislators views into policy and program formulation process. Modify implementation tactics.
Interest Group Opposition	Hold formal and informal briefings and meetings. Incorporate their views into policy and program formulation process. Appoint qualified persons to project advisory boards. Perform duties which will win their favor and support. Modify some aspects.

Table 1-3 Continued

OBSTACLES	ALTERNATIVE SOLUTIONS
Public Opposition	Poll public attitudes and opinions. Initiate public education program. Incorporate their views into policy and program formulation process. Have public representation on advisory boards. Provide incentives for changing opinion. Do some aspect of program which will yield spectacular results that will increase public support.

Just as its name implies, incremental implementation involves the gradual development of a program. Almost all existing state abatement and reclamation programs are incremental. The advantages and disadvantages of utilizing an incremental approach include:

> Advantages -- Long-range plans can be generated and adapted when obstacles occur. Allow for orderly transitions and progressive growth. Likelihood for effective opposition is decreased by developing implementation strategies which will not arouse negative public opinion.
>
> Disadvantages -- Program may become too rigid to accommodate abrupt changes in environmental, economic, social and political conditions.

The revolutionary approach of implementation involves abrupt changes. Revolutionary measures are not commonly used in abatement and reclamation programs. A crisis situation where there is an overwhelming consensus of opinion is an opportune situation in which to implement programs greatly departed from past performance. The advantages and disadvantages of this approach include:

> Advantages -- Immediate alteration of environmental, economic, social or political conditions. May revitalize a program - "get it out of ruts."

Disadvantages -- Likelihood for generating opposition increases. There may not be enough time for adequate planning.

As discussed in previous sections of this chapter, implementing agencies may be organized in several ways. Use of consulting services is another viable means of implementing various aspects of abatement and reclamation programs. Generally speaking, consultant services should be utilized when a state has:

1. Insufficient staff

2. Lack of staff expertise

3. Severe time deadlines

4. Lack of equipment

The criteria to be considered in selecting a specific consultant include:

1. Academic training

2. Job experience

3. Professional reputation

4. Previous job performance

5. Ability to meet deadlines

6. Current work schedule

7. Equipment capability

8. Cost of services

Advantages of Using Consultants

1. Are removed from subjective influences of political and social pressures. Study results and recommendations tend to be more objective.

2. Can mobilize their resources effectively and efficiently to meet severe time deadlines.

3. Provide new insights and observations to unusual problems.

4. Can generate several alternatives due to greater problem solving capacity.

5. Are familiar with new innovations and maintain active liaisons with other resource groups and persons.

6. Are not constrained by bureaucratic policy and procedures.

7. Tend to adopt positive attitudes in problem solving.

8. Maintain an inventory of high quality laboratory and field instrumentation.

Disadvantages

1. Oversight of political realities may render inappropriate recommendations.

2. Consultant costs may be higher than low cost budgets can absorb.

CHAPTER 2

LEGAL PROBLEMS AND AVENUES OF DEVELOPMENT

INTRODUCTION

The primary purpose of this legal chapter is to point out major legal and/or constitutional questions and problems which arise during implementation of pollution abatement and reclamation programs involving inactive or abandoned mined land. Each state's or subdivision of government's solution for handling these problems may vary significantly. Therefore, this chapter deals with the avenues and approaches to problem solutions, rather than expressing specific solutions.

Once it has been determined that a statewide pollution abatement and reclamation program for inactive and abandoned mine sites should proceed, legal mechanisms for implementing the program should be identified and evaluated. Legal means available for accomplishing reclamation will vary from state to state and may include use of federal, state, and local pollution control legislation, interstate compacts, public works programs, and judicial precedent concerning nuisance, property rights and related areas.

Analysis of available legal mechanisms will identify legal problems likely to be involved in establishing a program. Most obviously, conflicts are certain to arise between the most efficient means of accomplishing reclamation on one hand, and judicial precedent defining rights of property owners on the other. Barriers are likewise certain to result from inadequate legislation. Thus, effective implementation of a statewide pollution abatement and reclamation program for inactive and abandoned mine sites is likely to require changing, to whatever degree constitutionally permissible, inadequate and/or unreasonably restrictive legislation and judicial precedent. Legal mechanisms available as well as feasibility and difficultly of changing laws are significant factors to be considered, along with technical aspects of reclamation in setting forth a workable plan for inactive and abandoned mine pollution abatement.

DEFINITION OF LEGAL STATUS

Initially a state must define its legal status and mechanisms available to handle this complex abatement and reclamation program.

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A team of attorneys (either in-house or consulting law firm) should be utilized to research and digest current federal, state, county, local or watershed compact laws, such as:

1. Federal water pollution control laws
2. Federal mined land reclamation laws
3. State water pollution control laws
4. State mined land reclamation laws
5. State laws related to property ownership, mineral ownership, and state land acquisition (right of way, liens or eminent domain)
6. Relevant county, municipal and other local laws that may supplement or help establish state's jurisdiction

In addition to technical laws and jurisdiction legislature, all laws relevant to funding the program's admininistering agency, inventory surveys, feasibility studies, land acquisition and construction must be explored.

Final output from this initial legal investigation should be a report with sufficient detailed recommendations for action that would enable a bill to be introduced into state legislature which would provide legal authority to carry out pollution abatement and reclamation program for inactive and abandoned mined land. Major areas which should be covered by legislative authority are the following:

1. Public financing
2. Property acquisition and authority to sell property (or use of Lien)
3. Ability to cite abandoned mine landowners for problems which present a public health or safety hazard
4. Ability to buy and sell a mineral resource, if appropriate to abatement or reclamation
5. Authority to contract (negotiate) with private groups, universities, or government agencies
6. Authority to spend funds, accept funds, grants, gifts, services, loans, and utilize mineral severance tax money or other funding avenues
7. Authority to compensate mineral owners when their mineral becomes unmineable as a result of an abatement project (i.e. flooding a deep mine or regrading a strip mine)

8. Authority to make a clear distinction between abandoned and active operation (based on time or some finite parameter)
9. Authority to negotiate with active miners (including payment of an incentive) to have them reclaim abandoned mines adjacent to their active operation.
10. Authority to hire an in-house staff and/or contract with consultants to do planning, inventory design, preparation of construction plans and specifications, monitoring pollution from abandoned mines, supervise construction of abatement projects.
11. Authority to operate and/or monitor pollution control plants or projects on a long term basis
12. Authority to negotiate and/or compensate property owners who abate abandoned mine pollution at their own expense
13. Authority to assess (or have assessed) values of property before and after pollution abatement
14. Authority to prevent someone from later disturbing a pollution abatement project without becoming responsible for the recurring pollution (i.e. opening a sealed and flooded deep mine or reopening a reclaimed strip)
15. Ability to set abatement or reclamation standards and criteria
16. Authority to negotiate with other state agencies and with other states where abandoned mines are on state boundaries
17. Right of Entry Authority

Solution to many of these legal problems may be obtained by reviewing other states' relevant laws and discussions with their key personnel. Technology is often available from other state agencies which deal with similar problems, for example, land ownership, windfall profits, and funding. Contracting with private groups are dealt with daily by highway or transportation departments or agencies dealing with pollution control, public health or active mining.

Judicial Precedent

Earliest developments in controlling use of private land were in private lawsuits brought against private landowners. These suits, over time, developed a "nuisance theory" which gradually expanded into a theory permitting either public or private interests to bring an action against a private landowner to abate a condition that constituted a nuisance to surrounding lands and persons. The term "nuisance" is generally used in law to mean any condition on land which unlawfully and tortiously causes inconvenience, discomfort or injury to another and consists in doing an act or omitting to perform a duty, which act or omission damages, injures or endangers comfort, health, or safety of others or their property.

Nuisance law plies between two antithetical interests: right to use one's property for any purpose that one sees fit, and one's duty to use one's property in such a manner as not to injure property rights of one's neighbor. Nuisance cases required courts to strike a balance between these competing principles. Over the years, wisdom of the day and contemporary view of public policy have produced widely differing results in similar situations, even within the same state. A careful review of judicial precedent, therefore, must be made in any state considering a pollution abatement program for inactive and abandoned mine sites.

Legislation

Police power is the basis of authority in states and in municipalities to adopt laws which promote public health, safety, morals and general welfare. Police power includes in most states power to prevent and abate nuisances. Within constitutional limitations, legislature may define what constitutes a nuisance and the method for abatement of a nuisance. Accordingly, a careful review of all "statutory nuisances" should be undertaken with view to the intended pollution abatement program for inactive and abandoned mine sites. Such a review should include local units of government within a state because it is common for a state to have delegated abatement of certain nuisances to city boards of health, general health districts, or similar bodies. But most important source of existing legal mechanisms is likely to be state statutes in areas of air quality, energy, land use, resource recovery, solid waste management, water quality and related areas. A listing of relevant state laws (Table 2-1) gives an indication of the amount of legislative activity

Table 2-1
SYNOPSIS OF LAWS RELATIVE TO STATEWIDE POLLUTION ABATEMENT

AIR	WATER	SOLID WASTE – LAND USE
Alabama		
Air Pollution Control Act Air Pollution Control Rules and Regulations	Water Pollution Control Act Water Quality Criteria Procedural Regulations	Solid Waste Disposal Act Solid Waste Financing Act Solid Waste Management Regulations Standards for Disposal of Solid Wastes Surface Mining Act of 1969
Alaska		
Department of Environmental Conservation Act Air Pollution Control Regulations	Department of Environmental Conservation Act Water Quality Standards Wastewater Disposal Regulations Oil Pollution Regulations	Department of Environmental Conservation Act Solid Waste Management Regulations
Arizona		
Air Pollution Control Laws Rules and Regulations for Air Pollution Control	Water Pollution Control Law Rules and Regulations for Sewerage Systems and Waste Treatment Works Water Quality Standards	Solid Waste Rules
Arkansas		
Water and Air Pollution Control Act Air Pollution Control Code	Water and Air Pollution Control Act Regulations Establishing Water Quality Standards for Surface Waters	Solid Waste Management Act Solid Waste Disposal Regulations
California		
Air Pollution Control Laws Environmental Quality Act of 1970 Air Pollution Control Regulations Motor Vehicle Emissions Regulations	State Water Resources Control Board Water Pollution Control Laws Water Regulations	Solid Waste Management and Resource Recovery Act of 1972 Coastal Zone Conservation Act
Colorado		
Air Pollution Control Act of 1970	Water Quality Control Act	Solid Waste Disposal Sites and Facilities Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Colorado (continued) Air Quality Control Regulations Existing Wigwam Burners Regulations Existing Alfalfa Dehydration Plants Regulations Stationary Sources Standards Hydrocarbons Vapors Regulations	Regulations for State Discharge Permit System Water Quality Standards	Solid Waste Regulations
Connecticut Environmental Protection Act Air Pollution Control Laws Environmental Policy Act Rules of Practice Air Pollution Control Regulations	Clean Water Act Water Quality Standards	Solid Waste Management Act Solid Waste Management Services Act Regulation on Disposal of Refuse Public Utility Environmental Standards Act
Delaware Air Pollution Control Laws Regulation I - Definitions and Administrative Principles Regulation II - Registration and Permits Regulation III - Ambient Air Quality Standards Regulation IV to VII and XVIII - Particulates Regulations VIII and IX - Sulfur Dioxides Regulation XIII - Open Burning Regulation XIV - Visible Emissions Regulation XV - Air Pollution Alert and Emergency Plan Regulation XVI - Sources Having an Interstate Air Potential Regulation XVII - Source Monitoring, Record-Keeping and Reporting Regulation XIX - Control of Odorous Air Contaminants	Underwater Lands Laws Water Quality Standards Water Pollution Control Regulations River Basin Commission Regulations - Water Quality	Environmental Control Laws Solid Waste Disposal Regulations Coastal Zones Act Wetlands Act
District of Columbia Air Pollution Control Act	Water Pollution Control Law	Solid Waste Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
District of Columbia (Continued)		
Air Quality Control Regulations Diesel Exhaust Emissions Regulations	Water Pollution Control Regulations	Solid Waste Regulations
Florida		
Air and Water Pollution Control Act Environmental Protection Act of 1971 Administrative Procedures Air Pollution Rules Rules on Permits Open Burning and Frost Protection Fires Regulations Rules on Alternate Enforcement Procedure Pollution Control Tax Assessment Rules	Air and Water Pollution Control Act Sewage Disposal Facilities Law Pollutant Spill Prevention and Control Act Water Resources Act of 1972 Rules on Pollution of Waters Rules on Sewage Works Rules on Assessment of Damages	Resource Recovery and Management Act Garbage and Rubbish Rules Environmental Land and Water Management Act of 1972 Coastal Construction Law
Georgia		
Air Quality Control Law Vehicular Visible Emission Control Act Air Quality Control Rules	Water Quality Control Act Water Quality Control Regulations Water Classifications	Solid Waste Management Act Solid Waste Management Rules Coastal Marchlands Protection Act
Hawaii		
Environmental Quality Law Environmental Quality Council Law Environmental Quality Commission Law Air Pollution Regulations Ambient Air Quality Standards	Environmental Quality Law Water Pollution Control Regulations	Environmental Quality Law
Idaho		
Environmental Protection and Health Act of 1972 Air Pollution Control Regulations	Water Pollution Control Law Water Quality Standards and Wastewater Treatment Requirements	Solid Waste Law Solid Waste Regulations and Standards
Illinois		
Environmental Protection Act	Environmental Protection Act	Environmental Protection Act

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Illinois (Continued) General Air Pollution Regulations Stationary Sources Standards Air Quality Standards Episodes Regulations Open Burning Regulations Asbestos, Spray Insulation, and Fireproofing Regulations Mobile Sources Standards Odors Regulations	Water Pollution Control Rules Rules and Regulations on Cyanides on Cyanogen Compounds	Solid Waste Regulations
Indiana Air Pollution Control Law Environmental Management Act Environmental Policy Law Open Burning, Visible Emissions, and Indirect Heating Regulations Process Operations, Existing Foundries, and Incinerators Regulations Episode Alert Levels Sulfur Dioxide Regulations Ambient Air Quality Hydrocarbons Regulation Regulations on Carbon Monoxide and Nitrogen Dioxide Particulate Regulations Compliance Schedule Permits Regulation Fugitive Dust Regulation Air Quality Basins Regulation	Stream Pollution Control Law Phosphate Detergent Law Watercraft Sewage Disposal Law Water Quality Standards NPDES Permit Regulations Hazardous Substances Regulation	Refuse Disposal Act Anti-Litter Law Highway Junkyard Control Act Abandoned Vehicle Act Solid Waste Management Permit Regulations Industrial Waste Hauler Permit Regulation
Iowa Department of Environmental Quality Act Rules and Regulations Relating to Air Pollution	Department of Environmental Quality Act Water Quality Standards Confined Feeding Operations Regulations	Department of Environmental Quality Act Sanitary Disposal Projects Rules Surface Mining Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Kansas Air Quality Control Act Air Pollution Emission Control Regulations	Water Pollution Control Laws Water Quality Criteria Underground Storage Regulations Permits, Spills, and Charts Regulations Agricultural Wastes Regulations	Solid Waste Management Act of 1970 Solid Waste Disposal Act Solid Waste Management Standards and Regulations
Kentucky Environmental Protection Law General Provisions and Regulations Open Burning Regulations Particulate Emissions Regulations Sulfur Compound Emissions Regulations Hydrocarbon Emissions Regulations Carbon Monoxide Regulations Nitrogen Oxides Regulations Coal Refuse Regulations Ambient Air Quality Standards Rules of Practice Review of Indirect Sources	Environmental Protection Law Water Quality Standards Waste Discharge Permits Regulations Public Hearings Regulations Excessive Spills Discharges Regulations	Environmental Protection Law Garbage and Refuse Disposal Law Solid Waste Regulations Strip Mining Law
Louisiana Air Control Law Council of Environmental Quality Air Pollution Control Regulations	Stream Control Commission Acts Regulation on Reports of Industrial Waste Discharges Rules Relating to Oil and Gas Water Quality Criteria	Solid Waste Laws Solid Waste Regulations
Maine Air Pollution Control Law Air Pollution Control Rules Hearings Regulations	Water Pollution Control Law Oil Discharge Prevention and Pollution Control Act Oil Pollution Control Regulations	Solid Waste Management Act Solid Waste Management Regulations Land Use Law Site Location and Development Law Coastal Wetlands and Zoning Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Maryland		
Air Quality Control Act Environmental Policy Act Air Pollution Regulations	Water Pollution Control Laws Water Resources Law Environmental Service Act of 1970 Water Pollution Control Definitions Water Pollution Control Regulations Effluent Limitations Regulation on Toxic Materials for Aquatic Life Management Oil Prevention Regulation Discharge Permits Regulation Classification of State Waters Wastewater Works Regulation Water Pollution Control Principles Receiving Water Quality Standards Groundwater Quality Standards	Solid Waste Laws Solid Waste Regulations Power Plant Siting Act Strip Mining Law
Massachusetts		
Air Pollution Control Laws Environmental Cause of Action Law Environmental Protection Law Air Pollution Control Regulations Air Quality Standards	Clean Waters Act Rules for Adopting Administration Regulations for the Conduct of Adjudicatory Proceedings, and Administrative Rules Rules for the Prevention and Control of Oil Pollution in the Waters of the Commonwealth Hazardous Waste Regulations Water Quality Standards	Solid Waste Disposal Law Sanitary Landfill Regulations
Michigan		
Air Pollution Laws Environmental Protection Act of 1970 Administrative Rules for Air Pollution Control	Water Resources Commission Act Liquid Industrial Waste Disposal Act Cleaning Agents and Water Conditioners Act Watercraft Pollution Control Act General Provisions and Procedures Regulations Wastewater Reporting and Surveillance Fees Rules	Solid Waste Disposal Act Solid Waste Regulations Shorelands Protection Act

Table 2-1 Continued

AIR	WATER	SOLID WASTE – LAND USE
Michigan (Continued)	Hearings Regulations Oil Spillage Regulations Cleaning Agents Regulations Wastewater Discharge Permits Water Quality Standards Water Temperature Standards	
Minnesota Pollution Control Agency Law Environmental Council Act Environmental Rights Act Environmental Policy Act Ambient Air Quality Standards Air Quality Definitions Permits and Monitoring Rules Fuel Burning Rules Particulate Matter Rules Incinerator Rules Open Burning Restrictions Odor Control Rules Visible Air Contaminants Rules Gasoline Storage Rules Acid and Alkaline Emissions Rules Sulfuric Acid Plant Emissions Rules Nitric Acid Rules Emission Standards for Asbestos and Inorganic Fibrous Material Regulations for Permits for Indirect Sources	Water Pollution Control Laws Statutes Pertaining to Marine Toilets Oil Storage Regulations Criteria for Intrastate Waters Criteria for Interstate Waters Effluent Standards for Intrastate Waters Classification of Intrastate Waters Classification of Interstate Waters NPDES Regulations Criteria for Watercraft Sewage Retention Devices	Solid Wastes Recycling Law Solid Waste Disposal Regulations Critical Areas Act
Mississippi Air and Water Pollution Control Act Air Quality Regulations Permit Regulations Emergency Episodes Regulations	Air and Water Pollution Control Act Water Quality Criteria NPDES Regulations	Solid Waste Disposal Act of 1974 Solid Waste Regulations Sanitary Landfill Standards

Table 2-1 (Continued)

AIR	WATER	SOLID WASTE - LAND USE
Missouri Air Conservation Law Regulation S-I, Auto Exhaust Emission Controls Regulation S-II, Reporting of New Installations Regulation S-III, Open Burning Restrictions Regulation S-IV, Incinerators Regulation S-V, Restriction of Emission of Particulate Matter from Industrial Processes Regulation S-VI, Maximum Allowable Emissions of Particulate Matter from Fuel-Burning Equipment Used for Indirect Heating Regulation S-VII, Restriction of Particulate Matter from Becoming Airborne Regulation S-VIII, Restriction of Visible Air Contaminants Regulation S-IX, Restriction of Emission of Odors Regulation S-X, Restriction of Emission of Sulfur Compounds Regulation S-XI, Rules for Controlling Emissions During Periods of High Air Pollution Potential	Clean Water Law Waste Disposal Well Law Definition Regulation Discharge and NPDES Permits and Spills Regulations Effluent Regulations Miscellaneous Water Pollution Control Regulations	County Option Dumping Ground Law Junkyards Law Solid Waste Law Refuse Disposal Regulations Solid Waste Rules and Regulations
Montana Clean Air Act Air Quality Regulations	Water Pollution Control Law Water Use Act Environmental Policy Act Water Quality Criteria Regulation on Water Pollution from Livestock Feeding Pollutant Discharge Elimination System	Refuse Disposal Control Law Refuse Disposal Districts Law Refuse Disposal Regulation
Nebraska Environmental Protection Act	Environmental Protection Act	Environmental Protection Act

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Nebraska (Continued)		
Motor and Diesel-Powered Motor Vehicle Act Rules of Practice and Procedure Air Pollution Control Regulations	Water Quality Standards Domestic and Industrial Liquid Wastes Disposal Rules Livestock Waste Control Regulations Disposal Wells Regulations NPDES Regulations	Solid Waste Disposal Sites Law Solid Waste Control Rules
Nevada		
Air Pollution Control Law Air Quality Regulations	Water Pollution Control Laws Water Pollution Control Regulations	Solid Waste Disposal Law Solid Waste Management Regulations
New Hampshire		
Air Pollution Control Law Open Burning Regulations Fluorides Regulation Particulate Emissions Regulations Sulfur Emissions Regulations Incinerators Regulation Waste Burners Regulation Asphalt Plants Emissions Regulation Motor Vehicles Regulation Ferrous Foundries Regulation Ambient Air Quality Standards Sand, Gravel, and Cement Industries Regulation Nonferrous Foundries Regulation Pulp and Paper Industry Regulation Permit Regulation Process, Manufacturing, Service, Miscellaneous Industries Regulation Record Keeping Regulation Emergency Episode Regulation Requirements for Indirect Sources	Water Pollution Control Law	Waste Disposal Laws Junkyard Control Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
New Jersey		
Department of Environmental Protection Act of 1970 Air Pollution Control Laws Regulations on General Provisions and Open Burning Regulations on Smoke from Combustion of Fuel Regulations on Air Pollution from Manufacturing Processes Regulations on Sulfur Regulations on Permits and Certificates Regulations on Incinerators Regulations on Emergencies Ambient Air Quality Standards Regulations on Diesel-Powered Motor Vehicles Light-Duty Motor Vehicles Regulations	Department of Environmental Protection Act of 1970 Water Pollution Control Laws Water Quality Improvement Act of 1971 Clean Ocean Act Wetlands Act of 1970 Environmental Rights Act Point Source Discharge Regulations Surface Water Quality Standards	Solid Waste Laws Motor Vehicle Junk Law Waste Control Act Solid Waste Management Regulations Coastal Area Facility Review Act
New Mexico		
Environmental Improvement Act Air Quality Control Act Air Quality Standards and Regulations	Water Quality Act Water Quality Regulations Water Quality Standards	Solid Waste Management Regulations
New York		
Environmental Conservation Law Rules on General Provisions, Permits Stack Testing, Emergency Control Measures, and General Prohibition Processes and Exhaust and/or Ventilation Systems Contaminant Emissions from Ferrous Jobbing Foundries and By-Product Coke Batteries Rules on Open Fires Rules on Motor Vehicle Emissions Incinerator Rules Rules on Cement Plants and Asbestos	Environmental Conservation Law Watercraft Sewage Disposal Law Classifications and Standards Criteria Governing Thermal Discharges Rules on Use and Protection of Waters	Environmental Conservation Law Refuse Disposal Rules Wetlands Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
New York (Continued) Rules on Fuel Composition and Use Rules on Sulfuric Acid and Nitric Acid Plants Rules on Indirect Sources of Air Contamination Ambient Air Quality Standards		
North Carolina Water and Air Resources Acts Motor Vehicle Emissions Laws Rules and Regulations Governing the Control of Air Pollution	Water and Air Resources Acts Environmental Policy Act of 1971 Oil Pollution Control Act of 1971 Rules, Regulations, Classifications and Water Quality Standards Applicable to Surface Waters Monitoring Regulation	Solid Waste Disposal Law Solid Waste Disposal Regulations
North Dakota Air Pollution Control Act Air Pollution Control Regulations	Water Pollution Control Act Surface Water Quality Standards	Solid Waste Management Regulations
Ohio Air Pollution Control Laws General Air Pollution Regulations Regulations for Suspended Particulates and Sulfur Oxides Regulations for Carbon Monoxide, Hydrocarbons, and Photo-chemical Oxidants Regulations for Oxides of Nitrogen Permits System Regulations Regulations for the Prevention of Air Pollution Emergency Episodes Permit Fees Regulations Regulation on Air Permits to Operate and Variances Open Burning Regulation	Environmental Protection Agency Water Pollution Control Act Watercraft Sewage Disposal Law Criteria of Stream-Water Quality Resolution on Discharge of Toxics NPDES Permit Regulations Ohio River Valley Water Sanitation Commission Standards on Sewage and Industrial Wastes	Solid Waste Disposal Law Solid Waste Disposal Regulations Power Plant Siting Commission Law Reclamation Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE + LAND USE
Oklahoma Clean Air Act Pollution Control Coordinating Act of 1968 Regulation 1 - Open Burning Regulation 2 - Motor Vehicle Pollution Control Devices Regulation 3 - Definitions Regulation 4 - Air Contaminant Sources Registration Regulation 5 - Incinerators Regulation 6 - Particulate Matter Emission from Fuel-Burning Equipment Regulations 7, 8, 9, 10 - Smoke, Particulates, Hazardous Contaminants Regulations 11, 12, 13 - Malfunction, Sampling, and Monitoring Regulation 14 - Permits Regulation 15 - Organic Material Regulation 16 - Sulfur Oxides Regulations 17, 18 - Carbon Monoxide and Nitrogen Oxides	Water Pollution Control Laws Pollution Remedies Law Pollution Control Coordinating Act of 1968	Solid Waste Management Act Pollution Control Coordinating Act of 1968 Solid Waste Management Regulations
Oregon Air Pollution Control Laws Air Pollution Control Regulations	Water Pollution Control Laws Synthetic Cleaning Agent Water Quality Control Regulations	Solid Waste Management Law Solid Waste Regulations Land Use Law
Pennsylvania Air Pollution Control Act Air Pollution General Rules Standards for Contaminants Coal Refuse Disposal Rules Air Pollution Sources Rules Standards for Sources Ambient Air Quality Standards	Department of Environmental Resources Clean Streams Law Sewage Facilities Act Sewage Facilities Regulations Water Quality Criteria Water Resources General Provisions NPDES Permit Regulations	Solid Waste Management Act Solid Waste Regulations Surface Mining Conservation and Reclamation Act Erosion Control Regulations

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Pennsylvania (Continued)		
Local Air Pollution Control Agencies Rules Sources Reporting Rules Air Pollution Episodes Rules Sampling-Testing Rules Variances and Alternate Standards	Waste Water Treatment Regulations Industrial Wastes Regulations Mine Drainage Permits Sewage Facilities Grants	
Puerto Rico		
Department of Natural Resources Act Law on the Control of Air Pollution Air Pollution Control Regulations	Water Pollution Control Law Harmful Spills Law Public Policy Environmental Act	(NONE)
Rhode Island		
Clean Air Act Air Pollution Control Regulations Sulfur Content of Fuels Regulation Approval of Plans Regulation Air Pollution Episode Regulations Nitrogen Oxides Regulation Incinerator Regulation	Water Pollution Control Law Water Quality Standards	Solid Waste Law Coastal Resources Management Council Solid Waste Management Corporation Act
South Carolina		
Pollution Control Acts Air Pollution Control Regulations and Standards	Pollution Control Acts Classification Standards	Landfill Regulation Industrial Solid Waste Disposal Site Regulation Guidelines for Waste Disposal Permits
South Dakota		
Clean Air Act Air Pollution Control Regulations	Water Pollution Law Environmental Policy Act Water Quality Standards	Solid Waste Disposal Act Solid Waste Rules

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Tennessee		
Air Quality Act Air Pollution Control Regulations	Stream Pollution Control Law General Regulations Water Quality Criteria	Solid Waste Disposal Act Solid Waste Regulations Surface Mining Law
Texas		
Clean Air Act Air Control Board Regulations: General Provisions Regulation I: Control of Air from Smoke, Visible Emissions, and Particulate Matter Regulation III: Control of Air Pollution from Toxic Materials Regulation IV: Control of Air Pollution from Motor Vehicles Regulation V: Control of Air Pollution from Volatile Carbon Compounds Regulation VI: Control of Air Pollution by Permits for New Construction or Modification Regulation VII: Control of Air Pollution from Nitrogen Regulation VIII: Control of Air Pollution Emergency Episodes Regulation II: Control of Air Pollution from Sulfur Compounds Exemptions from Permits Procedures Permit System Procedures	Water Quality Act Water Quality Requirements, General Statement Water Quality Rules Water Quality Standards	Solid Waste Disposal Act Refuse Dumping Law Solid Waste Regulations Regulation on Disposal of Industrial Solid Waste
Utah		
Air Conservation Act Air Conservation Regulations	Water Pollution Control Act Definitions and General Requirements Water Quality Standards	Solid Waste Disposal Regulations
Vermont		
Air Pollution Control Law	Water Pollution Control Laws	Solid Waste Law

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Vermont (Continued)		
Air Pollution Control Regulations	Water Classification and Quality Regulations Pollution Charges and Permit Fees Rules NPDES Permit Program Regulations	Solid Waste Regulations Land Use Law Land Capability and Development Plan Law
Virginia		
Air Pollution Control Laws Council on the Environment Law Air Pollution Control Definitions Air Pollution Control Procedures Air Quality Standards Regulations on Open Burning, Smoke, and Visible Emissions Particulates Regulations Gaseous Contaminants Regulation Odor Regulations Coal Refuse Disposal Regulation Motor Vehicle Emissions Regulation Air Pollution Emergency Regulation	State Water Control Law Miscellaneous Laws Relating to Water Pollution Environmental Impact Report Law Water Pollution Control Regulations Water Quality Standards	Solid Waste Disposal Law Solid Waste Regulations
Washington		
Environmental Quality Reorganization Act of 1970 Clean Air Act State Environmental Policy Act of 1971 General Air Pollution Regulations Emergency Episode Plan Open Burning Regulations Field Burning Regulations Regulations on State Financial Aid Regulations on Reporting by Thermal Power Plants, Aluminum Plants, and Chemical Wood Wood Pulp Mills Regulations on Motor Vehicles Carbon Monoxide Standards	Water Pollution Control Laws Environmental Coordination Procedures Act of 1973 Department of Ecology Organization Waste Works Regulations Wastes Discharge Permits Water Pollution Control Planning Regulations Hearings Regulations NPDES Permit Program Regulations Water Quality Standards	Solid Waste Management Law Shoreline Management Act of 1971 Thermal Power Plant Siting Law Shoreline Development Permit Regulations

Table 2-1 Continued

AIR	WATER	SOLID WASTE - LAND USE
Washington (Continued) Regulations on Kraft Pulping Mills Sulfite Pulping Mills Regulations Suspended Particulate Standards Particle Fallout Regulations Photochemicals, Hydrocarbons, Nitrogen Dioxide Regulations Fluoride Standards Regulations on Primary Aluminum Plants Sulfur Oxide Standards Procedures Regulations Ecological Commission Regulations		
West Virginia Air Pollution Control Law Regulations on Coal Refuse Disposal Regulations on Combustion of Fuel in Indirect Heat Exchangers Regulations on Hot Mix Asphalt Plants Regulations on Odors Regulations on Coal Preparation Plants Regulations on Combustion of Refuse Regulations on Manufacturing Process Operations Ambient Air Quality Standards Regulations on Sulfur Oxides Regulations on Emergency Episodes Regulations on Permits	Water Pollution Control Act Water Quality Regulations	Solid Waste Laws Solid Waste Regulation Surface Mining Act
Wisconsin Air Pollution Control Laws Environmental Impact Law Ambient Air Quality Standards Air Pollution Control Rules	Water Pollution Control Law Discharge Permits Regulations Public Participation Procedures Interim Effluent Limitations for Pollution Discharge Elimination System Water Quality Standards	Solid Waste Law Environmental Quality Act
Wyoming Environmental Quality Act Air Quality Standards and Regulations	Protection of Public Water Supply Act Environmental Quality Act NPDES Permit Program Regulations Water Quality Standards	Solid Waste Disposal Law Solid Waste Management Rules

in these areas and need to review these enactments and attendant regulations in assessing available legal means for a statewide pollution abatement program for inactive and abandoned mine sites. These statutes are aggregated and reproduced from The Bureau of National Affairs, Environment Reporter -- State Air Laws, State Water Laws, and State Solid Waste -- Land Use.

Even though there has also been a great deal of federal activity, by way of legislation, executive orders, programs, etc., little has been done that is directly applicable to statewide pollution abatement programs for inactive and abandoned mine sites. This report is a major step in that direction, since it represents the federal government's attempt to support states in their efforts to respond to abatement and reclamation problems in their respective areas.

LEGAL PROBLEMS

Substantive legal problems arise at the very outset in deciding which of three conceivable parties is to bear the cost and burden of abatement: private landowner, current generation of miners, or the state.

If it is decided that the private landowner should be compelled to upgrade his property, a public nuisance statute is probably the most common means of enforcement. A large problem, however, looms in use of such statutes, for regulation of private land use comes close and often crosses the very thin line between acceptable exercise of a state's police power and an unconstitutional taking of private property for public use without just compensation. The range of cases dealing with balancing of competing principles is as broad as scholarly material is complex. Whenever a statutory or regulatory scheme restricts an individual's supposed right to do whatever he wants with his land, especially when the scheme is apparently new, constitutionality of the scheme is certain to be questioned. This delicate balance between needs of environmental protection and right of individual to control his own property makes litigation in early stages of a program a good possibility.

A second conceivable alternative is to place the burden of pollution abatement directly on current generation of miners for inactive and abandoned sites that were worked by previous generations of operators. There is, however, little or no judicial precedent that could be used to require outright the current generation of miners to cure abuses of prior generations. Any such statutory scheme would likely be unconstitutional for lack of due process and equal protection. Of course, operators are currently paying severance taxes in some states that are used to fund state pollution abatement programs. Developing criteria for reaffecting previously mined land using schemes such as tax breaks and licensing criteria, may be used to induce the current generation of miners to reaffect abandoned areas with new technology, and thus bring those lands under current standards for mine closing.

Finally, the state itself could accept responsibility for abating pollution from inactive and abandoned mine sites. The state could certainly reclaim land which is already owned. If state law permits, it might also acquire land in need of reclamation, specifically for the purpose of pollution abatement. The problem of a state doing reclamation work is not so much legal as economic; states with existing abatement programs have used various combinations of landowner, operator and state cooperation to abate pollution.

In 1973 Ohio's Board on Unreclaimed Strip Mined Lands and Department of Natural Resources funded a statewide pollution abatement program for inactive and abandoned coal mine sites. As part of this planning and inventory survey, a preliminary evaluation of its legal problems and available reclamation mechanisms was undertaken. To emphasize and cite specific examples of one state's legal avenues, some of Ohio's legal alternatives are presented here. Similar legal aspects, questions, and avenues of approach would also exist in other states. However, investigations of the legal complexities of each state will have to be performed to answer questions posed in this chapter.

Reclamation by Current Landowner

Use of Existing Nuisance Laws

There are several approaches by which unreclaimed mined lands could be declared a nuisance and landowners could possibly be forced to affect reclamation of those lands. The potential exists to accomplish this objective through common law action, statutory schemes, and water pollution control laws. These potential nuisance law remedies are discussed in the following pages.

Common Laws

Common law action against a private landowner for maintaining a nuisance is recognized in Ohio. While the maxim "sic utere tuo ut non alienum leadas" (use your property in such a manner as to not injure another) has frequently been employed by the courts as a major principle of nuisance law, the Ohio courts, including the Supreme Court, have taken a more restrictive view of permissible land use, permitting recovery under the nuisance theory for injuries beyond mere damage to property.

Remedies for a nuisance include recovery of damages, injunction against continuance or commission of the nuisance, and where the nuisance is one which is expressly prohibited by statute for which a criminal penalty is prescribed, a criminal prosecution of the offender. In the case of a private nuisance, the person injured may maintain an action at law for damages or, under proper conditions, maintain a suit in equity to have the creation or continuance of the nuisance enjoined. In case of a public nuisance, either the offender may be indicted or a suit may be filed on behalf of the state to abate the nuisance.

At common law, courts have used the nuisance theory to resolve conflicts, especially as to water quality, between mine operators on one hand and governmental bodies or owners of neighboring lands on the other. Each owner of land which abuts stream water was said to have a riparian right to use such water so long as he did not interfere with its reasonable use by other landowners. It was said to constitute an actionable nuisance for anyone to make discharges which would interfere with its reasonable use by others downstream. In the area of water quality control as in other areas of nuisance law, because balancing of antithetical principles is implicit in the nuisance theory, the law is a mass of widely disparate and contradictory judgments and results. For example, in an 1886 Pennsylvania case the Supreme Court of that State responded to a complaint by a downstream landowner of acidic water, dead fish and corroded pipes, saying:

> The defendants are engaged in a perfectly lawful business, in which they have made large expenditures and in which the interests of the entire community were concerned. They were at liberty to carry on that business in the ordinary way, and were not, while so doing, accountable for consequences which they could not control. As the mining operations went on, the water, by the mere force of gravity, ran out of the drifts, and found its way over to the defendant's own land to the Meadow Brook. It is clear that for the consequences of this flow, which by the mere force of gravity, naturally, and without fault of the defendants, carried the water into the small brook, and thence to the plaintiff's pond, and there could be no responsibility in damages on the part of the defendants.

Legal precedents in Ohio, however, indicate a tendency on the part of this State's highest court to give greater weight to the interest of surrounding landowners. As a result, Ohio law makes coal producers financially responsible at least nominally, for impairing the quality of stream water. In Straight v. Hover, 79 Ohio St. 263 (1909) plaintiff sued the defendant for allowing salt water to run off and pollute his stream after the defendant had separated salt water from oil extracted from his land. The defendant argued that he was using the most modern technique available and still could not prevent runoff. In addition, he claimed that the stream was part of the natural drainage basin of the area and that such runoff was therefore inevitable.

The court answered:

> However numerous may be the persons who engage in mining for coal and petroleum, however laudable may be their undertakings, these are but private enterprises instituted and conducted for private gain which may be acquired only with due regard to the rights of low proprietors.

This case involved an action against the landowner for the landowner's abuses. It should be noted, however, that under general leasehold principles in Ohio, a landowner is not responsible for wrongs commited by his tenant during the term of the lease unless he has participated in the wrong or has supervised or retained control over the tenant's activities. The argument that the continuous receipt of benefits by the landowner in the form of royalties and rents justifies imposing liability on him for harm resulting from the conduct which produces the royalties or rents has not met with significant success to date.

One can only guess at the reasons that the common law remedies have not proven adequate in abating pollution, especially pollution from unreclaimed strip mine lands. For one, a large percentage of such land is titled in private non-mining owners, and the courts historically have been unwilling to impose liability on private landowners other than miners. Secondly, as with many other legal rights, private persons often cannot justify to themselves the economics of bringing and maintaining a lawsuit, especially where, as in environmental and pollution areas, the results are so unpredictable and of such negligible direct economic value to an individual or small group of plaintiffs. Finally, the stripped acreage is so voluminous and the sources of pollution are so many that individual lawsuits involving individual parcels of land present monumental problems of proof and, even if successful, a seemingly insignificant impact on the total pollution problem.

Statutory Schemes

In recognization of the inadequacies of the common law remedies, various statutes have been enacted to supplement the common law means of controlling land use and to provide more effective and efficient means of controlling pollution. These statutory schemes are of varying degrees of assistance in compelling the landowner to reclaim his land in order to upgrade the environmental impact of his land.

The common law doctrine of nuisance as it pertains to orphaned lands, is discussed at some length above. As to the statutory action, Ohio Rev. Code 3767.02 provides that:

> Any person, who uses, occupies, establishes, or conducts a nuisance, or aids or abets therein, and the owner, agent, or lessee of any interest in any such nuisance together with the persons employed in or in control of any such nuisance by any such owner, agent, or lessee is guilty of maintaining a nuisance and shall be enjoined as provided in 3767.03 to 3767.06, inclusive, of the Revised Code.

Ohio Rev. Code 3767.03 to 3767.06 provide that whenever a nuisance exists;

> The Attorney General, the prosecuting attorney of the county in which such nuisance exists, or any person who is a citizen of such county may bring an action in equity in the name of the state, upon the relation of such Attorney General, prosecuting attorney, or person, to abate such nuisance and to perpetually enjoin the person maintaining the same from further maintenance thereof.

As used in all sections of the Revised Code relating to nuisances, "person" includes any individual, corporation, association, partnership, trustee, lessee, agent, or assignee.

Another statutory approach to the abatement of nuisances is contained in Ohio Rev. Code 3707.01 which provides that:

> The board of health of a city or general health district shall abate and remove all nuisances within its jurisdiction. It may, by order, compel the owners,

> agents, assignees, occupants, or tenants of any lot, property, building, or structure to abate and remove any nuisance therein, and prosecute such persons for neglect or refusal to obey such orders.
>
> When a building, erection, excavation, premises, business, pursuit, matter, or thing, or the sewerage, drainage, plumbing, or ventilation thereof is, in the opinion of the board, in a (condition dangerous to life or health) the board may declare it a public nuisance and order it to be removed, abated, suspended, altered, or otherwise improved or purified by the owner, agent, or other person having control thereof responsible for such condition, and may prosecute him for the refusal or neglect to obey such order. The board may, by its officers and employees, remove, abate, suspend, alter, or otherwise improve or purify such nuisance and certify the costs and expense thereof to the county auditor, to be assessed against the property and thereby made a lien upon it and collected as other taxes.

While this statutory scheme is not directly available to the Ohio Department of Natural Resources, it is an example of the statutory exercise of the police power which compels a landowner to make improvements.

Water Pollution Control Laws

The most active, topical and meaningful area of legislative activity, as it relates to orphaned lands, is the area of water pollution control. Even though the Ohio General Assembly passed an act on April 7, 1908, entitled "An Act to Authorize the State Board of Health to Require the Purification of Sewage and Public Water Supplies and Protect Streams Against Pollution," acid drainage and related pollutants are relative newcomers to the list of prohibited effluents. Chapter 6111 of the Ohio Revised Code, Water Pollution Control, was only recently amended to comply with the Federal Water Pollution Control Act Amendments of 1972. The breadth of these amendments is demonstrated by Ohio Rev. Code 6111.01(K) which defines "pollutant" to mean "any solid, liquid or gaseous matter or substance, including heat" and Ohio Rev. Code 6111.01(L) which defines "source of pollution" to mean "any building, structure, facility, installation, machine, device, apparatus, equipment or operation which directly or indirectly pollutes, may pollute, or causes the pollution of the waters of the state."

Ohio Rev. Code 6111.04 provides that "No person shall cause pollution. . . Any such action is hereby declared to be a public nuisance, except in such cases where the director of environmental protection has issued a valid and unexpired permit, or renewal thereof. . . ." Ohio Rev. Code 6111.03(J) provides that:

> A permit shall not be used unless the discharge of the source of pollution meets or will meet all applicable standards, including all state and federal water quality standards, effluent standards, pretreatment standards, regulations, and other requirements of Chapter 6111 of the Ohio Rev. Code. The Director may refuse to issue a permit for the discharge of pollutants when he finds that issuance of the permit would violate any federal law or regulation promulgated thereunder. The Director may set terms and conditions of permits, including, but not limited to conditions requiring schedules and programs for compliance with all applicable standards in order to prevent, control, or abate water pollution.

The sanctions in Chapter 6111 now provide that whoever knowingly or negligently violates certain sections of Chapter 6111 "shall be fined not less than Five Thousand ($5,000.00) Dollars, nor more than Twenty Five Thousand ($25,000.00) Dollars or imprisoned not more than one (1) year, or both. At least the minimum fine shall be imposed in all cases of conviction, and no sentence shall be suspended." Other sections carry fines of up to Twenty Five Thousand ($25,000.00) Dollars per day of violation.

While the Ohio water pollution control law is quite broad, it was neither intended nor written to deal specifically with orphaned lands. Many of the side effects of orphaned lands which effect water quality fall within the existing law as amended. However, the burden of reclamation could be more clearly imposed on the surface owners of abandoned strip mines and refuse piles, and owners of minerals in inactive mines with language such as the following from 691.316 of the Pennsylvania Clean Streams Law:

> Whenever the Sanitary Water Board finds that pollution or a danger of pollution is resulting from a condition which exists on land in the Commonwealth the board may order the landowner or occupier to correct the condition in a manner satisfactory to the board or it may order such owner or occupier to allow a mine operator or other person or agency of the Commonwealth access to the land to take such action. For the purpose of this section, 'landowner' includes any person holding title to or having a proprietary interest or either surface or subsurface rights.
>
> For the purposes of collecting or recovering the expense involved in correcting the condition, the board may assess the amount due in the same manner as civil penalties are assessed. . . .

In addition to amending the existing law and promulgating the necessary rules and regulations, the Ohio Environmental Protection Agency would probably need a special group of investigators and technicians to work in the field and augment present enforcement efforts.

Before any further discussion of possible legislative approaches to compelling the landowner to upgrade his property, it should be noted, in summary, that the applicable statutory law in Ohio is based on the nuisance theory. While the public nuisance statute is probably the most clearly defined avenue of enforcement the approach most likely to succeed is a statutory scheme analagous to that enacted as to boards of health but designed to compel the landowner to improve orphaned lands pursuant to the supervision of the Environmental Protection Agency.

Enactment of an Environmental Code

The last word certainly has not been written in regard to possible legislative schemes for placing the burden of reclamation on the private landowner. An approach might lie in requiring the landowner to bear the burden of environmentally upgrading his property by enacting new legislation in sufficient detail to require the owner of land to maintain certain environmental standards on his property. The onus would be on the owner to upgrade his property subject to some appropriate sanction. Similar responsibilities for improving land have been placed upon landowners by municipal housing codes. Under this alternative, the work would be done by the owner or contractor of his choosing, or by the State with assessment against the property. Apart from the political difficulty in getting such legislation passed, however, is the probability of a high incidence of default due to the disparity between the generally low tax valuation and the relatively high cost of reclamation. In essence, this approach envisions the enactment of an "environmental code" analogous to municipal housing codes and zoning regulations. The police power is the basis of the authority in the State in the municipality to enact and enforce such laws. The power to adopt laws which serve the public health, safety, morals and general welfare is vested in the General Assembly by Article II, Sec. 1 of the Ohio Constitution of 1851 which entrusts the legislative power of the State to that body.

In certain areas, the General Assembly has elected not to exercise the police power. For example, the State Legislature, through a series of enabling acts, has delegated planning and zoning powers to counties and townships thus granting to counties and townships the same zoning powers which are enjoyed by municipal corporations by virtue of the home-rule provisions of the Constitution of Ohio. In other areas, such as building standards, the State Legislature has elected to exercise its police powers acted in the interest of the public welfare. Even though it results in the impairment of the full use of property by the owner thereof, reasonable exercise of police power under such enactments does not constitute a "taking of private property" within the meaning of the constitutional provisions requiring compensation for the taking of property for public use and prohibiting the deprivation of property without due process of law. The enactment of an "environmental code" requiring the landowner to bear the burden of environmentally upgrading his property would therefore appear to be a viable legislative scheme, depending of course on the degree of restriction and weight of burden placed upon the landowner.

Incentive for Reaffecting Orphaned Lands

Another possible legislative scheme is similar to that discussed above in connection with the present generation of strip miners, i.e., granting concessions in connection with new permits so as to induce the reclamation of orphaned lands. The State could grant an exemption from taxation to motivate the remining and/or reclamation of orphaned lands. Exemption laws long have been recognized in Ohio, and it must be regarded as the settled policy of the State to allow certain property to be exempt from taxation. The fundamental ground for tax exemptions is a present benefit to the general public which is sufficient to outweigh the loss of tax revenue. Article 12, Sec. 2 of the Ohio Constitution of 1851 permits the enactment of tax-exemption legislation: the legislature has wide range in choosing subjects of taxation. Accordingly, the legislature could enact a statutory scheme of tax exemptions granted to particular persons or property, or to persons, corporations, or things of a particular class, aimed at remining and/or reclaiming orphaned lands. If this approach succeeded in generating remining activity, the 1972 Strip Mine Law would be applicable in that the State Division of Reclamation could then establish and enforce reclamation standards. In other words, the existing administrative machinery could be used to monitor the activity precipitated by the exemption. Moreover, this approach could create an ongoing response to the current economic constraints and technological developments in the field of remining previously strip mined lands. If this approach succeeded in generating reclamation activity independent of remining, it is likely that the present procedures for issuing permits could be used to administer such a program.

Another approach which is quite similar to the notion of tax exemptions is payment of a premium or bounty for the remining or reclamation of orphaned lands. As in the case of tax exemption, the statutory scheme reflects the need to bring the economics of remining and reclamation into balance with the economics of strip mining new lands. Funds could be made available pursuant to Ohio Rev. Code 1513.01 which provides that:

> The balance of monies paid into the strip mining administration and reclamation reserve fund shall be expended as soon as practicable after appropriation by the general assembly for the purpose of reclaiming land affected by strip mining. . . .

Similarly, Ohio Rev. Code 5749.02 provides that the excise tax levied on the privilege of engaging in the severance of natural resources from the soil of this State "shall be used for the furtherance of environmental protection activities of the State and for the reclamation of land affected by strip mining." As in the case of granting a tax exemption, there is a reasonable expectation that the existing Ohio Strip Mine Law could be used to administer any activity generated by this approach.

Still another approach to encouraging reclamation by way of development is to generate funds to finance land uses of a more intense nature, such as "new towns" encompassing commercial, industrial and residential development. Due to its limited applicability, this approach would be used in conjunction with other approaches. It would, of course, relate to a host of social and economic considerations far above and beyond the mere reclamation of the land. The funding might well be available on some kind of matching basis through one or more federal programs. In concert therewith or quite independent thereof, the State could use its bonding capacity to underwrite bond issues and to create a revolving fund to be used by private developers or political entities to develop strip mined lands. An example of using the State's credit is contained in Ohio Rev. Code 6121.06 which provides that:

> The Ohio Water Development Authority may, from time to time, issue water development revenue bonds and notes of the state in such principal amounts as, in the opinion of the authority, are necessary for the purpose of paying any part of the cost of one or more water development projects or parts thereof.

Pursuant to Ohio Rev. Code 6121.04(E), "The Ohio Water Development Authority may make loans and grants to governmental agencies for the acquisition or construction of water development projects...." The hundreds of millions of dollars deployed by the Ohio Water Development Authority are adequate testimony to the viability of this approach.

Summary

In summary, then, at least three possible legislative schemes place the burden of reclamation on the private landowner. The enactment of an "environmental code" analagous to a housing code, is quite possible but rather unlikely in light of the obvious political difficulties and the probable high incidence of default due to the disparity between the value of the land and cost of reclamation. Another approach would be either granting tax exemption or paying a premium for the remining and/or reclamation of orphaned lands so as to make reclamation a more economically attractive alternative. This benefits private landowners who would receive royalty payments for subsequent mining and coal company landowners who would realize lowered mining costs. Lastly, the State might use its bonding capacity and available federal matching funds to enable private landowners to develop orphaned lands into residential, commercial and industrial sites.

A caveat must be expressed which touches upon the entire issue of compelling the landowner to reclaim his own land. Since the issue is essentially one of land use regulation, the threat is ever present that the attempt to solve the unreclaimed strip mine land problem by regulation of land use will exceed the very thin line between the acceptable exercise of the State's police power and the unconstitutional taking of private property for public use without just compensation. The distinction in any given case or in regard to any given statutory scheme is not clear. The range of cases dealing with the balancing of the competing principles is as broad as the scholarly material is complex. Suffice it to note, however, that whenever a statutory or regulatory scheme restricts an individual's supposed right to do whatever he wants with his land, especially when the scheme is apparently new, the constitutionality of the scheme will be in question. While the regulation of surface mining has fared rather well in the balancing of these principles and courts have approved statutory requirements that a mine operator treat his own wastes, the delicate balance between the needs of environmental protection and the right of the individual to control his own property must always be borne in mind.

Reclamation by Mining Companies

The second party on whom the responsibility of doing work of reclamation might be placed is the current generation of strip miners, i.e., those strip miners currently mining in Ohio. The focus of this section, as for the entire Report, is on the conceivability of compelling or persuading the current generation of strip miners to do the actual work of reclamation as opposed to them merely bearing the burden of cost for such reclamation. The cost issue, at least in part, has been decided by the Legislature's enactment of Ohio Rev. Code 1513.18 by which the cost of reclamation is placed on the current generation of strip miners.

The current generation of strip mine operators is at once the least likely candidate and the most likely candidate to look to for accomplishing the work of reclaiming orphaned lands. The operator is the least likely candidate since there is no common law theory which could realistically be used, even stretched, to compel the current generation of strip mine operators to do the work of reclaiming lands owned by another, which lands were stripped and left orphaned years before by previous generations of operators. Even if some common law theory did exist or could be conjured up to place vicarious liability on the current generation for the ravages of previous generations, monumental practical problems would arise such as determining which of the several operators currently at work in Ohio would be liable for the reclamation of particular parcels of land. Even if such practical problems as well as problems raised by the statutes of limitations and the obvious political problems could be resolved, to require a strip miner to remedy an environmental or land use situation on lands of another which he did not create would pose insurmountable constitutional problems relating particularly to due process and equal protection. This reason alone is enough to account for the apparent absence of any existing or proposed legislation which would compel the current generation of strip mine operators to reclaim orphaned lands.

Persuasive measures are, however, at least conceivable for inducing the current generation of operators to remedy the abuses of their predecessors. One method of inducing the generation of strip miners currently operating in Ohio to reclaim orphaned land is to amend Chapter 1513 to include a statutory condition of obtaining a license that the operator undertake to reclaim more land than he strips, perhaps even land designated by the State Division of Reclamation. The economics and therefore the political acceptability of such a scheme are improbable.

A method, however, of achieving much the same results is to attempt to persuade the license applicant to reaffect areas adjacent to or near the site for which the applicant seeks license. So, rather than making the reclamation of orphaned lands a statutory condition for the issuance of a license, this approach would depend upon the State Division of Reclamation persuading the operator to rework unreclaimed areas close to his intended field. The Chief of the Division presently has discretion in the issuance of a license, so he might exchange time and other concessions for the operator's agreement to reaffect unreclaimed areas nearby. Tax rebates and other benefits could be devised by the Legislature as further inducements to the current generation operator to reaffect orphaned areas. The State of Pennsylvania has used this persuasion method of accomplishing the work of reclamation and, according to sources, has found it productive, so much so that in the opinion of persons knowledgeable of Pennsylvania's attempts to reclaim orphaned lands, this persuasion approach is the easiest method as well as the method least costly to the State for dealing with the problem of unreclaimed lands. It uses the expertise of the current generation of strip mine operators, takes advantage of modern technology's ability to mine profitably land previously abandoned as no longer workable and costs the State the least both in terms of tax dollars and legislative effort.

In summary, then, as for placing the burden of doing the work of reclamation on the current generation of strip miners, the feasibility of compelling them to correct the abuses of their predecessors is limited and most unlikely. Persuading the operators during the licensing process to reaffect areas previously mined, however, has proven elsewhere to be the most productive method of dealing with the unreclaimed strip mine land problem. That method, with added tax and other benefits, has the potential for remedying a good deal of the problem unreclaimed strip mine land as it exists in Ohio.

Reclamation by the State

The two approaches to the problem of effecting reclamation discussed above are approaches in which the state is essentially the party merely occasioning efforts by private parties to environmentally upgrade lands affected by strip mining. Neither approach can envision the state taking an active role in the actual work of reclamation. The conceptual alternative exists, however, in which the State of Ohio itself would be the party actually doing the work of reclamation. In reclaiming orphaned land, the State could do the work in any of three ways: (1) reclaim the land for the private landowner himself; (2) reclaim land which the State itself owns or which it has acquired for the purposes of reclamation; (3) reclaim land in which the State has acquired a long-term possessory interest or for the private landowner himself.

Privately Owned Land

The possibility of the State of Ohio doing the work of reclamation on land privately owned and in which the State has no long-term possessory interest is a conceivable manner for the State to do the work of reclamation. Nothing in the Constitution of the State of Ohio appears to prohibit the legislature from providing the Department of Natural Resources or other State agency with the authority to agree with a private person to have the State reclaim the private person's land. In fact, authority exists from which it can be inferred that the State presently has the power to reclaim lands for the private owner with his consent. The Director of the Department of Natural Resources has been granted broad powers in order to carry out the purposes of the Department of Natural Resources. Among the powers granted the Director by Ohio Rev. Code 1501.01 is the power to acquire interests in real property other than the full and complete ownership. The powers of the Director are given to him in addition to the powers given the various divisions and he may exercise his powers on behalf of the various divisions. By the authority given to the Director, the Department of Natural Resources could acquire an easement onto the land of the private owner and reclaim it. Although reclamation on private land for the private owner appears to conflict with the terms of Ohio Rev. Code 1513.20 which authorizes the State Division of Reclamation to reclaim only on lands owned by the State, this alternative can be inferred from the statutory powers of the Director of the Department of Natural Resources.

It should be expected also that there would be strong political opposition to a plan which has the appearance of so directly and significantly benefiting a limited number of private landowners, especially because the possibility would always exist that the land owner, unless somehow restricted, might lease the mineral rights or otherwise permit the land to be strip mined if a new vein is discovered or as mining technology develops. Of course, the threat of the landowner undoing the reclamation could be minimized if the State, while bargaining for the easement, would also bargain for a covenant restricting specified activities which would have the effect of undoing the reclamation. A restrictive covenant runs with the land and would be equally binding on any person to whom the private owner would convey all or any part of his title to the land.

While existing law may be read to empower the State of Ohio to reclaim land for a private owner with the owner's consent, there is no specific authority for the State to enter upon private land without the owner's consent in order to reclaim his land. Legislation granting an agency of the State such power, however, is not without precedent. Local health districts, for example, are granted the power under Ohio Rev. Code 3737.02 to enter upon privately owned land in order to abate and remove any nuisance within its jurisdiction. The cost of labor and material necessary to perform the work are recorded as a lien against the property. A similar statute might be enacted giving the State Division of Reclamation like authority to enter upon lands found to have detrimental environmental effect as a result of strip mining, and to reclaim the land regardless of the owner's wishes. In drafting such a statute, however, care should be taken to limit the amount of the resulting lien to the value of the property after the work is completed since serious constitutional questions are raised by the assessment of liens in excess of the property value.

In summary, the present state of the law would permit the State of Ohio to reclaim lands for a private owner. An agreement with the private owner would be necessary, however, since the present state of the law does not permit the State of Ohio to improve the lands owned by a private person against the person's will.

Publicly Owned Land

The alternative to the State reclaiming land for the private landowner is for the State to do the reclamation for itself, i.e., for the Department of Natural Resources to reclaim State lands in order to advance the purposes set forth in the act which created the Department of Natural Resources, 123 Ohio Laws 94. The State Division of Reclamation has clear authority under Ohio Rev. Code 1513.20 to reclaim lands which the State owns or which it acquires for the purpose of reclamation. Such lands may be acquired by purchase, gift or donation or be the exercise of the Department of Natural Resources' power of eminent domain.

Although Ohio Rev. Code 1513.20 appears to limit the power of the State to reclaiming only those lands to which the State holds full title, the conceptual alternative exists for the State to reclaim lands in which it has only a leasehold interest, i.e., an interest in land for a term of years. A question exists whether this avenue is possible under the current law of Ohio and in light of the Ohio Constitution. Although Ohio Rev. Code 1513.20 limits the reclamation activity of the Division of Forestry and Reclamation to state owned land, the limitation does not extend to the Department of Natural Resources. The Director of the Department of Natural Resources is granted by the provisions of Ohio Rev. Code 1501.01 the authority to lease lands in order to further the purposes of the Department of Natural Resources and this authority to acquire interests in land is expressly stated to be in addition to any power of acquisition granted to any other division of the Department. Since this power according to Ohio Rev. Code 1501.01 may be exercised by the Director on behalf of any division, it can be inferred from the law as it presently exists that the Department of Natural Resources has the power to reclaim on leased lands. This power, however, is inferred from several statutes, and the statutes from which the inference is drawn are subject to more than one interpretation. The authority of the Department of Natural Resources to reclaim on lands in which it holds only a leasehold interest would be indisputable with but a slight amendment of Chapter 1513 of the Ohio Rev. Code.

A further difficulty with reclamation of lands in which the State holds only a leasehold interest is the apparent problem presented by Art. II, Sec. 22 of the Ohio Constitution of 1851. That Section seems to limit the State's authority to enter into agreements which would delegate the General Assembly to appropriate funds for more than one two-year period. Since the Department would be spending large amounts of money to reclaim land seemingly for the benefit of private owners, unless the State acquires full title to the land, the Department of Natural Resources should be expected to require at least a long-term lease in the land to be reclaimed. If indeed Art. II, Sec. 22 prohibits entering into long-term leases, the Department of Natural Resources could enter into a two year lease with a series of two year options, thus giving the State the right to claim a continuing interest in the land for an extended period.

While the State is reclaiming lands which it owns or in which it holds a leasehold interest, assuming the leasehold interest includes mineral rights, the Department of Natural Resources appears to have the power to sell any coal mined during the reclamation effort, regardless of whether done under the express authority of the State Division of Reclamation or under the implied authority of the Department of Natural Resources. The proceeds from such sales would be credited to the general revenue fund for the State. The money would go to the General fund only because no rotary fund exists for the State Division of Reclamation. If such a fund were created, money realized from the sale of the coal would be credited to that fund and it would ultimately have the effect of offsetting the cost of reclamation since any money left after operating expenses of the division at the end of the division's fiscal year, are credited to the Strip Mining Administration and Reclamation

Reserve Fund. It is from that fund that monies for reclamation are drawn.

Land owned by the State which has been reclaimed may be sold by the Department of Natural Resources under authority of Ohio Rev. Code 1513.01.

MODEL LEGISLATIVE APPROACH

The obvious approach to implementation of a statewide pollution abatement program for inactive and abandoned mine sites is enactment of new legislation or clarification of existing laws that respond to technical aspects of mineral commodity extraction while minimizing possibility of legal challenges to its enactment and implementation. Model legislation in the area of pollution control and abatement has been published by the Council of State Governments and others (Table 2-2) which could be of assistance in drafting a statute. Because of existing State statutes and judicial precedent, the following is an outline or checklist that could be useful in preparing a legislative proposal.

- Purpose
- Definitions
- Organization
  - Creation of Agency, Bureau, etc. and possible Advisory Committee
  - Director or other Administrative Officer Staff
  - Composition of Board, Advisory Committee, etc.
- General Powers and Duties
- Intergovernmental Relationships, i.e. interstate

- Scope of Regulatory Power
- Pollution Abatement Standards
  - Air
  - Water
  - Noise
  - Soil Conservation
  - Reclamation
- Prohibition of Discharges

- Issuance and Duration of Permits
    - General Terms and Conditions of Permits
- Requirement of Permit -- Prior Approval
- Application for Permit
    - Background Information
    - Operating Plan
    - Pollution Abatement Plan
- Consideration of Application
- Issuance of Permits
    - Payments of Fees
    - Performance Bond
    - Rights Created by Permit
    - Revocation, Modification or Suspension
    - Inspection and Entry
    - Public Access to Information

- Programs, Projects and Facilities
    - General Powers
    - Inventory of Mining Operations
    - Pollution Abatement Projects
        - Acquisition of Interests in Land
        - Exercise Power of Eminent Domain

- Emergency Powers

- Compliance Orders

- Injunctive Relief

- Civil Penalties

- Criminal Penalties

- Financing
    - Loans
    - Bonds
    - Pollution Abatement Fund

- General Provisions

Table 2-2
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CHAPTER 3

PROGRAM FUNDING POSSIBILITIES

PROGRAM FUNDING POSSIBILITIES

This chapter is designed to serve as a beginning point for any agency undertaking the task of reclaiming abandoned mined lands. Much financial and technical assistance is available from federal, state, local and private sources. It is important to note that the lead times required to secure financial assistance from most agencies are quite long.

Sources of assistance are divided into two major sections: (1) agencies that can supply financial assistance as well as technical, planning and management information, (2) agencies that supply only technical assistance (which may be in the form of information, equipment or manpower).

In addition to sources of aid described in the following sections, any state agency, local government officials or private interest groups exploring feasibility and requirements of abandoned mined land restoration, particularly for recreation benefits, should contact the Liaison Officers of the Bureau of Mines and State Liaison Officers to the Bureau of Outdoor Recreation. These people can supply additional financial and technical aid and requirements at state and local levels. The listing of these offices is found in Tables 3-1 and 3-2 at the end of this chapter (81).

POSSIBLE FUNDING SOURCES

Federal

Federal assistance, in the form of loans, formula grants, and project grants, is available through many agencies. Although funding legislation may not explicitly direct monies to abandoned mine pollution abatement, financing can still be obtained, providing conditions of the funding agency are met. Abatement programs can be implemented as a part of another program, such as forestry development, rural housing projects, agricultural land development and improvement, and overall community land use improvement projects.

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Project grants and formula grants are important sources of abatement program funds. Federal agencies providing such grants that could be applicable to state projects include:

1. Department of Agriculture
    - Agricultural Stabilization and Conservation Service
    - Forest Service
    - Farmers Home Administration
    - Soil Conservation Service
2. Department of Interior
    - Bureau of Mines
    - Bureau of Outdoor Recreation
    - Bureau of Sport Fisheries and Wildlife
3. Environmental Protection Agency
    - Office of Water and Hazardous Materials
    - Office of Research and Development
4. Department of Commerce
    - Economic Development Administration
5. Department of Housing and Urban Development
6. Appalachian Regional Commission (Appalachian States only)
7. Water Resources Council

State

The responsibility of obtaining funds for implementation of a statewide abatement of pollution from orphan mined lands program need not rest on a single state agency. A coordinating department can solicit funds and assistance from other branches. For example, State Parks Departments should be consulted for advice and financial aid where abatement programs could result in new state recreation areas; Fish and Game Commissions could supply funds where abatement programs improve sport fishing and/or hunting opportunities.

In any event, the major source of abatement program funding will result from legislature allocations of the State's general appropriation budget. Full legislative support is necessary if a successful pollution abatement program is desired.

Reclamation and pollution control monies can also be supplied by performance forfeitures from active mines. In the future, much of a state's resources for actual reclamation construction will be derived from state and federal severence taxes on active mineral production.

Local

Local governments can sometimes provide sufficient funds to carry out projects within their jurisdiction. Preparation of detailed plans and procedures should be supplied by a State agency to insure that results will be compatible with the overall abatement program. In addition, many local governments are able to finance only project implementation, and not problem identification, planning, and abatement design. If given the opportunity, various local governments would be very willing to assist in carrying out programs that would benefit their community, if monies are available.

Private

Although not now a major source of program revenue, private organizations, such as environmental groups, sportsmen associations (hunting and fishing), trade associations and area improvement committees, can supply supplemental funds for specific projects. In some cases, these groups will even provide volunteer labor to assist in completing some smaller projects. State agencies should not hesitate contacting these organizations and explaining abatement program plans of interest to the individual groups. Private groups can serve to arouse community support for state projects in areas where implementation problems with private landowners prevail.

If an economic benefit can be gained by reclaiming abandoned or inactive mines, private industry can sometimes be persuaded to execute pollution control projects. For example, if a current pollution source could be converted into an industrial park site, an agreement could be reached where the state would release the land to the private company, provided current pollution problems are alleviated.

FUNDING AGENCIES AND PROGRAMS

The federal government also provides financial assistance in the form of Direct Loans and Guaranteed/Insured Loans to state and local governments, private individuals, and non-private organizations or sponsors. In some instances, states can provide private landowners with a detailed water pollution abatement plan, and they in turn can apply to federal agencies for cost-sharing loans and grants. The Farmers Home Administration of the Department of Agriculture offers five loan programs which could be utilized to some extent for pollution abatement work at inactive or abandoned mine sites.

1. Resource Conservation and Development Loans
2. Rural Housing Site Loans
3. Soil and Water Loans
4. Watershed Protection and Flood Prevention Loans
5. Irrigation Drainage and other Soil and Water Conservation Loans

The Economic Development Administration of the Department of Commerce also offers Direct Loans for an area's economic growth, which could have application to an abatement program in some instances.

Federal funds are available for agencies involved at all levels of reclamation from planning, lands inventory, feasibility studies, engineering design and actual construction which includes all types of land uses. Descriptions of these agencies' program objectives, limitations, eligibility and funding follow this section (45, 81).

Appalachian Regional Commission

Appalachian Regional Development Program

Authorization: Appalachian Regional Development Act of 1965; Public Law 89-4 as amended by Public Law 90-103; Public Law 91-

123 and Public Law 92-65; 40 App. U.S.C. 1-405.

Objectives: To stimulate substantial public investments in public facilities that will start the region on its way toward accelerated social and economic development; to help establish a set of institutions in Appalachia capable of permanently directing the long-term development of the region; and on a joint federal-state-local basis, to develop comprehensive plans and programs to help accomplish the overall objectives of Appalachian development.

Types of Assistance: See individual Appalachian program description following for details.

Uses and Use Restrictions: Appalachian funds enable the states and local areas to develop networks of facilities and services. The individual programs following this description illustrate the types of investments that can be made. In considering programs and projects to be given assistance under this act, and in establishing a priority ranking of the requests for assistance presented to the Commission, the Commission follows procedures insuring consideration of the following factors: (1) the relationship of the project or class of projects to overall regional development, including its location in an area determined by the state as having a significant potential for growth; (2) the population and area to be served by the project or class of projects including the relative per capita income and the unemployment rates in the area; (3) the relative financial resources available to the state or political subdivision or instrumentalities thereof which seek to undertake the project; (4) the importance of the project or class of projects in relation to other projects or classes of projects which may be in competition for the same funds; (5) the prospects that the project for which assistance is sought will improve on a continuing rather than a temporary basis, the opportunities for employment, the average level of income, or the economic and social development of an area served by the project; and (6) no financial assistance can be used (a) to assist establishments relocating from one area to another;

(b) to finance the cost of industrial plants, commercial facilities, machinery, working capital, or other industrial facilities or to enable plant subcontractors to undertake work theretofore performed in another area by other subcontracts or contractors; (c) to finance the cost of facilities for the generation, transmission, or distribution of electric energy; or (d) to finance the cost of facilities for the production, transmission, or distribution of gas (natural, manufactured, or mixed). Each state is required by the Commission to file a State Appalachian Development Plan annually, appraising prospects for development in its Appalachian area and relating to them all projects for which Appalachian funding is requested in that year. Once a project is approved by the Commission, the grant is administered by the basic federal agency involved in that type of program.

Eligibility Requirements: Applicant Eligibility: (a) states, and through the states, public bodies and private nonprofit organizations; and (b) limited dividend organizations are eligible for the Appalachian housing fund. All proposed projects must meet the requirements of the State Appalachian Plan.

Financial Information:

Account Identification: 04-02-0090-0-1-507; 04-02-4190-0-3-507.
Obligations: See individual Appalachian Commission programs.
Range and Average of Financial Assistance: Not Applicable.

Appalachian Mine Area Restoration Program

Authorization: Section 205, Appalachian Regional Development Act of 1965; Public Law 89-4, as amended by Section 110, Public Law 90-103 Section 105, Public Law 91-123, and Section 207, Public Law 92-65; 40 App. U.S.C. 205.

Objectives: To further the economic development of the region by rehabilitating areas presently damaged by deleterious mining practices and by controlling or abating mine drainage pollution, and to meet the objectives stated under the program entitled Appalachian Regional Development (23.001).

Types of Assistance: Project Grants.

Uses and Use Restrictions: Seal and fill voids in abandoned coal mines and abandoned oil and gas wells; reclaim and rehabilitate lands affected by strip and surface mining and by processing of coal and other minerals including land affected by waste piles, extinguish underground and outcrop mine fires, and control or abate mine drainage pollution; activities to reclaim strip-mined areas are limited to lands owned by federal, state, or local bodies of government otherwise meeting the restrictions stated under program entitled Appalachian Regional Development (23.001).

Eligibility Requirements:

Applicant Eligibility: states and through the states, public bodies owning strip-mined land in need of restoration are eligible. The States are eligible to apply for assistance to seal and fill voids in abandoned coal mines, plan and execute projects for the extinguishment and control of underground and outcrop mine fires, seal abandoned oil and gas wells.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: The state must demonstrate that the project area has a use that contributes to the economic development investment in the region. Projects must conform to the State Appalachian Plan which is submitted annually on or before July 1. A State Plan coordinated with the Governor's office is required under Part III of OMB Circular No. A-95 (revised).

Financial Information:

Account Indentification: 04-02-0090-0-1-507.

Obligations: (Grants) FY 74 est $14,174,974; and FY 75 est $4,980,000.

Range and Average of Financial Assistance: $165,000 to $6,171,165; $2,290,000.

Appalachian Supplements to Federal Grant-in-Aid Program

Authorization: Section 214, Appalachian Regional Development Act of 1965. Public Law 89-4; as amended by section 116, Public Law 90-103; and section 107, Public Law 91-123; and section 210, Public Law 92-65; 40 App. U.S.C. 214.

Objectives: To provide supplemental funds to increase the federal contribution for projects of construction, land acquisition, and/or equipment for eligible applicants, who, because of their economic situation cannot supply the required matching share of the basic federal program and to provide special basic grants where there are sufficient funds available under the basic Federal Grant-in-Aid Program to meet the pressing needs of the region.

Types of Assistance: Project Grants.

Uses and Use Restrictions: The grants may be used for providing supplemental funds under any Federal grant-in-aid programs authorized on or before December 31, 1974. The special basic grants are new. To be eligible for special basic grants, projects must be of high priority in the State's Appalachian Development Plan and either of critical importance to a phased investment and development program for a multi-county area, or of unusual economic benefit to such an area. Refer to Appalachian Regional Development program (23.001) and section 214 of the Appalachian Regional Commission Code for additional use restrictions.

Eligibility Requirements:

Applicant Eligibility: states, and through the states, their subdivisions and instrumentalities and private nonprofit agencies.

Beneficiary Eligibility: General public.

Credentials/Documentation: Any finding, report, certification, or documentation required to be submitted to the head of the department, agency, or instrumentality of the Federal

Government responsible for the admininstration of the basic Federal Grant-in-Aid Program shall be accepted by the Federal Co-chairman with respect to a supplemental grant for any project under such a program. Projects must conform to the State Appalachian Plan which is submitted annually on or before July 1. A State Plan, coordinated with the Governor's office is required under Part III of OMB Circular No. A-95 (revised).

Financial Information:
Account Identification: 04-02-0090-0-1-507.
Obligations: (Grants) FY 73 $39,512,567; FY 74 est $37,975,607; and FY 75 est $46,400,000.
Range and Average of Financial Assistance: $2,200 to $1,124,000; $237,000.

Possible Use: In areas designated under the Appalachian Act, financial assistance can be procured to abate mine drainage pollution and sedimentation problems from abandoned or inactive mine sites, owned by federal, state, or local government. Funded projects must further the economic development of the region and coincide with the overall regional development program. Direct grants to pollution abatement projects are common funding approaches.

Department of Agriculture, Agricultural Stabilization and Conservation Service

Rural Environmental Conservation Program (RECP)

Authorization: The Soil Conservation and Domestic Allotment Act, February 29, 1936.

Objectives: To help farmers, ranchers, and woodland owners carry out approved soil, water, woodland, forestry and wildlife conservation practices, to assure wise use and adequate protection of the Nation's agricultural lands.

Types of Assistance: Cost-sharing grants to individuals.

Uses and Use Restrictions: Agricultural land only.

Financial Information: $90 million FY 74.

Possible Use: Where surface mining has destroyed agricultural areas, or where reclamation of mined lands could result in additional agricultural land, states could provide a conservation or abatement program to private landowners, who in turn could apply to this agency for cost-sharing funds to improve his land for agricultural usage.

Department of Agriculture, Farmers Home Administration

Irrigation, Drainage, and Other Soil and Water Conservation Loans

Authorization: Consolidated Farm and Rural Development Act, Section 306; PL 92-419.

Objectives: To increase income of farm families and other rural residents, and to readjust the use of land so that each acre is used for a purpose which will better serve the community.

Types of Assistance: Loans to public or quasi-public bodies.

Uses and Use Restrictions: Irrigation, drainage, or other soil conservation measures designed to serve farmers or rural residents.

Financial Information: $1,000,000 est FY 74; $1,000,000 est FY 75.

Possible Use: In previously mined areas where extensive erosion and sedimentation cause economic problems to rural residents, and where mined land condition is not serving a purpose to the community, loans could be obtained from this agency by state or local government to implement an abatement program.

Rural Housing Site Loans

Authorization: Housing Act of 1949 as amended, Sections 523 and 524; PL 89-117 and PL 89-754.

Objectives: To assist public or private nonprofit organizations interested in providing sites for housing, to acquire and develop land in rural areas to be subdivided as adequate building sites and sold on a nonprofit basis to eligible low and moderate-income families, cooperatives, and nonprofit applicants.

Types of Assistance: Direct Loans, Guaranteed/Insured Loans.

Uses and Use Restrictions: For the purchase and development of adequate sites, including necessary equipment which becomes a permanent part of the development; for water and sewer facilities if not available; payment of necessary engineering, legal fees, and closing costs; for needed landscaping and other necessary facilities related to buildings such as walks, parking areas, and driveways. Restrictions: loan limitation of $100,000 without national office approval; loan funds may not be used for refinancing of debts, payment of any fee, or commission to any broker, negotiator, or other person for the referral of a prospective applicant or solicitation of a loan; no loan funds will be used to pay operating costs or expenses of administration other than actual cash cost of incidental administrative expenses if funds to pay those expenses are not otherwise available.

Eligibility Requirements:

Applicant Eligibility: A private or public nonprofit organization that will provide the developed sites to qualified borrowers on a nonprofit basis.

Beneficiary Eligibility: (1) Families eligible for low- and moderate-income Section 502 Rural Housing Loans, including self-help housing; (2) rural cooperative housing applicants and broadly based non-profit rural rental housing applicants, and (3) applicants eligible for HUD Section 235 and 236 insured mortgages.

Credentials/Documents: Applicant must furnish evidence of the following: (1) market analysis showing need for such services; (2) legal capacity to borrow funds and develop land for sale; and (3) a sound budget.

Financial Information:

Account Identification: 05-75-5-4141-0-3-352.

Obligation: (Direct Loans) FY 73 $9,100; FY 74 est $900,000; and FY 75 est $900,000 (Insured Loans) FY 73 $2,283,120; FY 74 est $5,000,000; and FY 75 est $3,000,000.

Range and Average of Financial Assistance: (Direct) $9,100. (Insured) $58,700 to $570,000; $376,225.

Possible Use: In areas where orphan mined lands causing pollution problems can be restored or reclaimed to housing sites, public agencies can utilize this funding program. A pre-determined land use plan including a community layout with lot subdivisions, roads, walks, utilities, etc. is necessary. Pollution abatement can be achieved in conjunction with development of rural areas for housing. Note that not all pollution source areas can utilize these funds.

Resource Conservation and Development Loans

Authorization: Food and Agriculture Act of 1962; Public Law 87-703 1011 (Supp. V) 1959-63; 7 U.S.C. 1010.

Objectives: To provide loan assistance to local sponsoring agencies in authorized areas where acceleration of program of resource conservation, development, and utilization will increase economic opportunities for local people.

Types of Assistance: Guaranteed/Insured Loans

Uses and Use Restrictions: Loan funds may be used for (1) rural community public outdoor-oriented water based recreational facilities; (2) soil and water, development, conservation, control and use facilities; (3) shift in land use facilities; (4) community water storage facilities and (5) special purpose equipment to carry out the above purposes. Project must be located in an authorized RCD area. Total indebtedness for a single RCD measure cannot exceed $250,000.

Eligibility Requirements:

Applicant Eligibility: Public agencies and local nonprofit corporations in authorized Resource Conservation and Development Areas may be eligible for loan assistance provided they: (1) are a sponsor of the RCD measure for which a loan is requested and which is included in REC project plan; (2) have authority to borrow funds, repay the loan and pledge security for the loan and to operate the facilities or services provided; and (3) are financially sound and so organized and managed that it will be able to provide efficient service.
Beneficiary Eligibility: Same as applicant eligibility.
Credentials/Documentation: Evidence of legal capacity, financial responsibility and economic feasibility relative to the activity for which assistance is requested.

Financial Information:

Account Identification: 05-75-4140-0-3-351.
Obligations: (Loans FY 73 $3,225,010; FY 74 est $3,600,000; and FY 75 est $3,600,000.
Range and Average of Financial Assistance: $6,000 to $250,000; $99,000.

Possible Use: If pollution sources from abandoned or inactive mines are located in authorized Resource Conservation and Development areas, loans can be obtained from the FHA by public agencies to carry out abatement programs. Land use plans involving public outdoor water oriented recreation, soil and water conservation practices nearly any increased land use value and/or water storage facilities will assist in obtaining these loans. Pollution abatement can be achieved through development of orphan mined lands to a useful purpose.

Soil and Water Loans

Authorization: Consolidated Farm and Rural Development Act, Subtitle A, Section 304, Public Law 92-419; 7 U.S.C. 1924.

Objectives: To facilitate improvement, protection, and proper use of farmland by providing adequate financing and supervisory assistance for soil conservation; water development, conservation, and use; forestation; drainage of farmland; the establishment and improvement of permanent pasture; and related measures.

Types of Assistance: Guaranteed/Insured Loans.

Uses and Use Restrictions: Level land; carry out basic land treatment practices, including liming, fertilizing, and seeding; establish permanent pastures and farm forests; establish forestry practices; improve irrigation; develop water supplies for home use and livestock; purchase pumps, sprinkler systems and other irrigation equipment; acquire water rights, restore and repair ponds and tanks, ditches, and canals for irrigation; dig ditches and install tile to drain farmland; develop ponds and water control structures for the production of fish under controlled conditions.

Eligibility Requirements:

Applicant Eligibility: (1) be unable to obtain credit from other sources at reasonable terms and conditions; (2) be of legal age; (3) be of good character; (4) have the necessary experience, training, and managerial ability to carry out the proposed operation.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Applicant must establish that credit is not available elsewhere for the requested purpose.

Financial Information

Account Identification: 05-75-4140-0-3-351.

Obligations: (Loans) FY 73 $3,974,930; FY 74 est $3,000,000, and FY 75 est $3,000,000.

Range and Average of Financial Assistance: $1,400 to $100,000; $5,300.

Possible Use: Loans can be obtained by private landowners to develop pollution forming mined areas into useful agricultural land. State agencies could provide private landowners with a sound abatement program whereby the owner could then apply for assistance from this agency to carry out the plan. Items covered by the loan include land leveling, liming, fertilizing, seeding, irrigation, and water supply facilities.

Watershed Protection and Flood Prevention Loans

Authorization: Watershed Protection and Flood Prevention Act of 1954, as amended, Section 8; U.S.C. 1006a.

Objectives: To provide loan assistance for the local sponsors and share of the cost of watershed works of improvement for flood prevention, irrigation, drainage, water quality management, sedimentation control, fish and wildlife development, public water based recreation and water storage and related costs. The total amount of WS loans outstanding in any one watershed cannot exceed $5,000,000.

Eligibility Requirements:

Applicant Eligibility: To be eligible for a watershed loan an applicant must: (1) be a sponsoring local organization such as municipal corporation, soil and water conservation district, or other organization not operated for profit of the approved watershed project and (2) have authority under state law to obtain, give security for and raise revenues to repay the loan and to operate and maintain the facilities to be financed with the loan.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Evidence of legal capacity, economic feasibility and financial responsibility relative to the activity for which assistance is requested.

Financial Information:

Account Identification: 05-75-4140-0-3-351.

Obligations: (Loans) FY 73 $19,964,100; FY 74 est $20,400,000; and FY 75 est $20,400,000.

Range and Average of Financial Assistance: $7,230 to $2,000,000; $227,286.

Possible Use: Where pollution abatement programs can be shown to benefit watershed conditions (sedimentation control, water quality improvement, flood prevention, fish and wildlife development), loans can be obtained by local sponsors to carry out the programs. States can provide the detailed procedures of the project to local agencies who in turn need only to implement the plans. Costs of an entire watershed improvement scheme can be distributed over several smaller sponsors, with each responsible for only a portion of project funding.

Department of Agriculture, Forest Service

Assistance to States for Tree Planting and Reforestation

Authorization: Agriculture Act of May 28, 1956, (70 Stat. 207; 16 U.S.C. 568c - 568g).

Objectives: To provide assistance to states in their forestation and tree improvement projects that will help assure an adequate supply of timber.

Types of Assistance: Project Grants.

Uses and Use Restrictions: To assist states in undertaking needed programs of tree planting, other forestation and tree improvement activities. Reforestation work is carried out to restore low-yielding or nonproductive forest lands to fuller production. New or expanded tree improvement projects are funded under this program in cost-sharing arrangements.

Eligibility Requirements:

Applicant Eligibility: State Forestry agencies.

Beneficiary Eligibility: The landowners (private and non-Federal agencies) are the ultimate beneficiaries of the program efforts.

Credentials/Documentation: A plan for forest land tree planting, reforestation and tree improvement is submitted to the Forest Service. A cooperative agreement covers arrangements for all participating states.

Financial Information:

Account Identification: 05-96-1100-0-1-402.
Obligations: (Grants) FY 73 $786,000; FY 74 est $746,000 and FY 75 est $1,012,000.
Range and Average of Financial Assistance: $2,000 to $60,000; $18,200.

Possible Use: Where mining activities have disrupted forest resource areas and are causing pollution problems, states can obtain grants from this federal agency to develop those areas into productive forest lands. Reforestation work can eliminate current pollution sources and restore these lands to full forest production potential.

Department of Agriculture, Soil Conservation Service

Watershed Protection and Flood Prevention

Authorization: Water Protection and Flood Prevention Act; Public Law 83-566, 68 Stat. 666; Public Law 84-1018, 70 Stat. 1088; Public Law 85-624, 72 Stat. 563; Public Law 85-865, 72 Stat. 1605; Public Law 86-468, 74 Stat. 131, 132; Public Law 86-545, 74 Stat. 254; Public Law 87-170, 75 Stat. 408; Public Law 87-703, 76 Stat. 608; Public Law 89-337, 79 Stat. 1300; Public Law 90-361, 82 Stat. 250; Public Law 92-419, 86 Stat. 667.

Objectives: To provide technical and financial assistance in planning and carrying out works of improvement to protect, develop, and utilize the land and water resources in small watersheds.

Types of Assistance: Project Grants; Advisory Services and Counseling.

Uses and Use Restrictions: Assistance is provided in planning, designing and installing watershed works of improvement; in sharing costs of flood prevention, irrigation, drainage, sedimentation control, fish and wildlife developments, and public recreation; and in extending long term credit to help local interests with their share of the costs. Watershed area must not exceed 250,000 acres. Capacity of a single structure is limited to 25,000 acre feet. See also Farmers Home Administration program 10.419, Watershed Protection and Flood Prevention Loans.

Eligibility Requirements:

Applicant Eligibility: Any state agency, county or groups of counties, municipality, town or township, soil and water conservation district, flood prevention or flood control district, or any other nonprofit agency with authority under state law to carry out, maintain and operate watershed works of improvement may apply for assistance.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Applicants must designate the proposed project area, be properly signed and attested to by all applicants, set forth the need for the proposed project, Gubernatorial review of the State Plan is required under Part III of OMB Circular No. A-95 (revised).

Financial Information:

Account Identification: Watershed and flood prevention operations, 05-78-1072-0-1-401; Watershed planning, 05-78-1066-0-1-401.

Obligations: (Grants and salaries and expenses-watershed and flood prevention operations) FY 73 $125,865,198; FY 74 $166,434,485; and FY 75 est $140,281,601; (Grants and salaries and expenses-watershed planning) FY 73 $6,834,736; FY 74 est $10,766,396; and FY 75 est $11,335,000.

Range and Average of Financial Assistance: $20,000 to $10,000,000; $2,000,000.

Possible Use: In areas where small watersheds are adversely affected by abandoned or inactive mine sites, government agencies can obtain grants from this agency to achieve flood control, irrigation, drainage and sedimentation control, water quality improvement, fish and wildlife development, and public recreation. Incorporating orphan mined land pollution abatement into an entire small watershed improvement plan can open avenues for funding from this agency.

Resource Conservation and Development

Authorization: Food and Agriculture Act of 1962; Public Law 87-703; 76 Stat. 607; U.S.C. 1010, 1011 (Supp. V) 1959-1963; Public Law 91-343; 7 U.S.C. 1011 (e); Public Law 74-46; Public Law 92-419.

Objectives: To assist local people in initiating and carrying out long-range program of resource conservation and development for purposes of achieving a dynamic rural community with satisfactory level of income and pleasing environment, and creating a favorable investment climate attractive to private capital.

Types of Assistance: Project Grants; Advisory Services and Counseling.

Uses and Use Restrictions: Technical planning assistance is available only for project area authorized for such planning. Technical and financial assistance is available for the installation of land conservation and land utilization works of improvement specified in project plans. Works of improvement may include measures serving purposes such as flood prevention, sedimentation and erosion control, public water based recreation and fish and wildlife developments, agricultural water management purposes, rural community water supply, water quality management, control and abatement of agriculture-related pollution, disposal of solid wastes, and rural fire protection. See also Federal Housing Administration program 10.414, "Resource Conservation and Development Loans."

Eligibility Requirements:

Applicant Eligibility: Public agencies and organizations with authority to plan or carry out activities relating to resource use and development.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Applicant agency (s) must document fact that application is made as a result of official ac-

action of the governing body. Applications are honored only from agencies for which applicant eligibility as shown above is or has been established.

Financial Information:

Account Identification: 05-78-1010-0-1-354.

Obligations: (Grants and salaries and expenses) FY 73 $21,889,661; FY 74 est $23,876,000; and FY 75 est $24,347,440.

Range and Average of Financial Assistance: $2,000 to $250,000; $20,000.

Possible Use: In underdeveloped rural areas, where long-range programs of resource conservation and development can be initiated, mined land pollution sources can be eliminated by incorporating abatement procedures into an overall area improvement program. Project areas must be authorized by this agency prior to planning. Once approved, financial and technical assistance can be obtained to carry out the proposed programs.

Department of Commerce,
Economic Development Administration

Economic Development - Grants and Loans for Public Works and Development Facilities

Authorization: Public Works and Economic Development Act of 1965; Public Law 89-136, as amended by Public Law 90-103, 91-123, 91-304, 92-65, and 93-46; 42 U.S.C. 3131, 3135, 3141, 3161, 3171.

Objectives: To assist in the construction of public facilities needed to initiate and encourage long-term economic growth in designated geographic areas where economic growth is lagging behind the rest of the Nation.

Types of Assistance: Project Grants; Direct Loans.

Uses and Use Restrictions: Grants for such public facilities as water and sewer systems, access roads to industrial parks or areas, port facilities, railroad sidings and spurs, public tourism facilities, vocational schools, flood control projects, and site improvements for industrial parks. Qualified projects must fulfill a pressing need of the area and must: (1) tend to improve the opportunities for the successful establishment or expansion of industrial or commercial plants or facilities, (2) assist in the creation of additional long-term employment opportunities, or (3) benefit the otherwise substantially further objectives of the Economic Opportunity Act of 1964. In addition, proposed projects must be consistent with the currently approved overall economic development program for the area, and for the district, if any, in which it will be located.

Eligibility Requirements:

Applicant Eligibility: States, local subdivisions thereof, Indian tribes, and private or public nonprofit organizations or associations representing a redevelopment area or a designated economic development center are eligible to receive grants and loans. Corporations and associations for profit are not eligible.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Application must describe the type of proposed facility, estimated costs, extent of proposed project, direct job impact, estimated time for construction implementation, and assurance that the project will satisfy statutory requirements. Most important, documentation must demonstrate how the project will have a positive impact on the economic development process in the community. A State Plan, coordinated with the Governors Office, is required under Part III of OMB Circular No. A-95 (revised).

Financial Information:

Account Identification: 06-10-2050-0-1-507

Obligations: (Grants) FY $215,018,000; FY 74 est $130,000,000; and FY 75 est $132,000,000. (Loans) FY 73 $4,906,168; FY 74 est $3,000,000; and FY 75 est $3,000,000.

Range and Average of Financial Assistance: No specific minimum or maximum project amount. $5,000 to $7,138,000; $580,000.

Possible Uses: Funding from this agency to abate pollution from mined lands is possible. In underdeveloped areas, where abandoned or inactive mined lands show promise for assistance in the economic development of a community (sites for schools, industrial parks, tourist facilities), grants and loans could be obtained. Many special conditions must be met in order to qualify for financial assistance including:

1. Projects must fulfill a pressing need for area development.
2. Projects must tend to improve economic potential of the community.
3. Assist in proving long-term employment potential.
4. Must be consistent with overall economic development program for the area.

Department of the Interior, Bureau of Mines

Mineral Resources and Environmental Development

Authorization: Grants for Support of Scientific Research, Public Law 85-934; Contracts for Scientific and Technologic Research; Public Law 89-672; 42 U.S.C. 1891 and 1900.

Objectives: To further the Bureau of Mines internal research program in accomplishing its mission by providing for grants and contracts for related research, development, and demonstration.

Types of Assistance: Project Grants; Research Contracts.

Uses and Use Restrictions: Assistance is intended to enhance the Bureau of Mines mineral resources and environmental development programs which are directed toward the conservation, development and efficient utilization of minerals and fossil fuels essential to the Nation's economy. Additionally, the research will help to eliminate air and water pollution, recover and reclaim waste materials formerly discarded into the environment, and minimize occupational hazards to workers in the mineral industry.

Eligibility Requirements:

Applicant Eligibility: Public agencies, industrial organizations not for profit, individuals, institutions of higher education or organizations with appropriate capabilities for the conduct of scientific research.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: The application should include a statement as to the nature of the organization, its offices, principal business, experience, and special qualifications for conducting the project for which application is being made.

Financial Information:

Account Identification: 10-32-0592-0-1-403.

Obligations: (Grants and contracts) FY 73 $3,500,000; FY 74 est $8,000,000; and FY 75 est $45,000,000.

Range and Average of Financial Assistance: $10,000 to $3,000,000; $150,000.

Possible Use: In areas where abatement programs can involve application and demonstration of new techniques, project grants can be obtained from this agency. States can obtain information on current research programs, and assist in providing sites for their demonstration, eliminating pollution sources with research fundings.

Federal Agency: Department of the Interior, Bureau of Outdoor Recreation.

Department of the Interior, Bureau of Outdoor Recreation

Outdoor Recreation - Acquisition, Development & Planning

Authorization: 16 U.S.C. 1-4 et seq. Land and Water Conservation Fund Act of 1965; Public Law 88-578; 78 Stat. 897; as amended by Public Law 90-401 (82 Stat. 354); Public Law 91-485 (84 Stat. 1084); Public Law 91-308 (84 Stat. 410); Public Law

92-347 (86 Stat. 460). and Public Law 93-81 (87 Stat. 178).

Objectives: To provide financial assistance to the states and their political subdivisions for the preparation of comprehensive statewide outdoor recreation plans and acquisition and development of outdoor recreation areas and facilities for the general public, to meet current and future needs.

Types of Assistance: Project Grants.

Uses and Use Restrictions: Acquisition and development grants may be used for a wide range of outdoor recreation projects, such as picnic areas, inner city parks, campgrounds, tennis courts, boat launching ramps, bike trails, outdoor swimming pools, and support facilities such as roads, water supply, etc. Facilities must be open to the general public and not limited to special groups. Development of basic rather than elaborate facilities is favored. Priority consideration generally is given to projects serving urban populations. Fund monies are not available for the operation and maintenance of facilities. Grants are also available to states only for revising and updating existing state outdoor recreation plans, preparation of new plans and for statewide surveys, technical studies, data collection and analysis and other planning purposes which are clearly related to the refinement and improvement of the state outdoor recreation plan.

Eligibility Requirements:

Applicant Eligibility: Only the state agency formally designated by the Governor of the state legislature to administer the state's Land and Water Conservation Fund Program is eligible to apply for acquisition and development grants. (Treated as States in this regard are the District of Columbia, Puerto Rico, the Virgin Islands, American Samoa, and Guam). Only the state agency formally designated by the Governor or state law is responsible for the preparation and maintenance of the state outdoor recreation plan is eligible for planning grants. For acquisition and development grants, the above state agency may apply for assistance for itself, or on behalf of other state agencies or political subdivisions, such as cities, counties, and park districts. Additionally, Indian tribes which are organized to govern themselves and perform the function of a municipal government qualify for

assistance under the program. Individuals and private organizations are not eligible.
Beneficiary Eligibility: The general public. For planning grants, same as applicant eligibility.
Credentials/Documentation: The state liaison officer, appointed by the Governor to administer the program in the state, must furnish assurance that the project is in accord with the State Comprehensive Outdoor Recreation Plan; i.e., that it meets high priority recreation needs shown in the action program portion of the plan. The state's apportionment balance of fund monies must be adequate for the project, and the sponsoring agency must permanently dedicate the project to public outdoor recreation and assume responsibility for operation and maintenance. State plans must cite the state's legal authority to participate in the Land and Water Conservation Fund program.

Financial Information:
Account Identification: 10-16-5005-0-2-405.
Obligations: (Grants) FY 73 $212,075,000; FY 74 est $170,000,000; and FY 75 est $220,000,000.
Range and Average of Financial Assistance: $150 to $5,450,000; $68,178.

Possible Use: Pollution sources from orphan mined lands can be eliminated while developing that area into an outdoor recreational facility. Construction of camping, picnicing, hiking, and swimming areas, developed from abandoned or inactive mine sites, can be financed through project grants from this agency. The recreation plan must be part of a statewide outdoor recreation program, and must be open to the general public upon completion. Fund monies provide for land acquisition, planning, and site development.

Department of the Interior, Bureau of Sport Fisheries and Wildlife

Fish Restoration

Authorization: Federal Aid in Sport Fish Restoration Act of 1950; 64 Stat. 430; as amended 16 U.S.C. 777-777k.

Objectives: To support projects designed to restore and manage sport fish populations for the preservation and improvement of sport fishing and related uses of these fisheries' resources.

Types of Assistance: Formula Grants.

Uses and Use Restrictions: Approvable activities include land acquisition, development, research and coordination. Activities prohibited are law enforcement and public relations.

Eligibility Requirements:

Applicant Eligibility: Participation limited to state fish and game departments. States must have passed laws for the conservation fees paid by fishermen for purposes other than the administration of the state fish and game department.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Notification of desire to participate must furnish a certification of the number of paid fishing license holders.

Financial Information:

Account Identification: 10-18-9999-0-2-405.

Obligations: (Grants) FY 73 $12,642,939; FY 74 $13,205,000; and FY 75 est $16,000,000.

Range and Average of Financial Assistance: $146,300 to $731,500; $286,750.

Possible Use: If pollution abatement from abandoned mine sites can provide areas for sport fishing opportunities, state fish and game departments can obtain money from this federal agency to improve and/or develop sport fishing in designated areas. Controlling sedimentation and improving water quality in acceptable streams are essential aspects of developing a sport fishing program.

Environmental Protection Agency, Office of Research and Development

Water Pollution Control - Research, Development, and Demonstration

Authorization: Sections 104,105, 107, 108, 113, of the Federal

Water Pollution Control Act as amended; Public Law 92-500; 33 U.S.C. 1254, 1255, 1257, 1258, 1263.

Objectives: To support and promote the coordination and acceleration of research, development, and demonstration projects relating to the causes, effects, extent, prevention, reduction and elimination of water pollution.

Types of Assistance: Project Grants.

Uses and Use Restrictions: Available for allowable direct cost expenditures incident to research performance plus allowable portions of allowable indirect costs of the institution, in accordance with established EPA policies.

Eligibility Requirements:

Applicant Eligibility: Nonprofit institutions such as universities and colleges, hospitals, laboratories, state and local government departments, other public or private nonprofit institutions, grants may also be awarded to individuals and persons who have demonstrated unusually high scientific ability.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentations: None.

Financial Information:

Account Identification: 20-00-0107-0-1-404.

Obligations: (Grants) FY 73 $16,773,429; FY 74 est $15,053,000; and FY 75 est $13,000,000.

Range and Average of Financial Assistance: (Research Grants) $2,750 to $502,354; $47,536; (Demonstration Grants) $5,000 to $487,788; $127,169.

Possible Use: Although not adaptable to wide usage in a state's abatement program, funds from this agency can be used to finance demonstration projects that prevent, reduce, or eliminate water pollution. In cases where state agencies cannot obtain funding, the state can suggest or donate demonstration sites to other organizations who can acquire allocations from this office.

Environmental Protection Agency,
Office of Water and Hazardous Materials

Water Pollution Control - State and Interstate Program Grants

Authorization: Section 106 of the Federal Water Pollution Control Act, as amended; Public Law 92-500; 33 U.S.C. 1256.

Objectives: To assist state and interstate agencies in establishing and maintaining adequate measures for prevention and control of water pollution.

Types of Assistance: Formula Grants.

Uses and Use Restrictions: Broad support for the prevention and abatement of water pollution including permitting, pollution control studies, planning, surveillance and enforcement; advice and assistance to local agencies; training; and public information. Funds cannot be used for construction, operation, or maintenance of waste treatment plants, nor can they be used for costs financed by other Federal grants or by funds used for matching other Federal grants.

Eligibility Requirements:

Applicant Eligibility: State and interstate water pollution control agencies as defined in the Federal Water Pollution Control Act. Agencies making application for funds must submit annually their pollution-control program to the appropriate Regional EPA Administrator for approval. Requirements of the program are based on Section 106 of the Act, and 40 CFR Part 35.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: A State Plan is required under Part III of OMB Circular No. A-95 (revised).

Financial Information:

Account Identification: 20-00-0108-0-1-404.

Obligations: (Grants) FY 73 $22,600,000; FY 74 est $40,000,000; and FY 75 est $40,000,000.

Range and Average of Financial Assistance: $65,000 to $2,368,770; $150,000.

Possible Use: States can utilize formula grants from this federal agency to develop pollution control programs. Studies can be conducted to identify and evaluate pollutional sources and recommend solutions. However, actual construction funding is not permitted.

Water Resources Council

Water Resources Planning

Authorization: Water Resources Planning Act; Public Law 89-80; 42 U.S.C. 1962 d-1.

Objectives: Provides grants for increased participation by the states in water and related land resources planning.

Types of Assistance: Formula Grants.

Uses and Use Restrictions: State preparation of water and related land resources plans, participation in federal-state comprehensive water and related land resources planning, and training of personnel, where necessary, to develop additional technical planning capability.

Eligibility Requirements:

Applicant Eligibility: The 50 States, the District of Columbia, Puerto Rico and the Virgin Islands. Applicant must be a state agency designated by law or the Governor to administer the water and related land resources planning.

Beneficiary Eligibility: Same as applicant eligibility.

Credentials/Documentation: Not applicable.

Financial Information:

Account Identification: 33-35-0100-0-1-401.

Obligations: (Grants) FY 73 $3,000,000; FY 74 $3,000,000; and FY 75 est $2,400,000.

Range and Average of Financial Assistance: $25,000 to $101,900; $60,000.

Possible Use: In conjunction with the federal government, states can prepare water and related land resource plans with funds from this agency. This planning can outline water related land use policies and establish areas in need of pollution control measures. Abatement projects can then be developed in accordance with the overall plan.

AVENUES FOR TECHNICAL ASSISTANCE

A matrix of problems exists in rectifying the abandoned mine land in any state. The vast interdiscipline expertise necessary to resolve the years of environmental damage from this land rarely are found in any one organization or government agency. Coordination of data collection, planning, evaluation, study and construction can be accomplished by utilizing information and assistance from a diverse group of federal, state, private and industrial sources. Technical information and research results are available to anyone interested in reclaiming abandoned land and abating mine drainage pollution from local universities, colleges, mining companies and environmental groups, in addition to the federal agencies described in this section. Restoration agencies should not overlook the help which can be obtained from agencies such as the Youth Conservation Corps, Job Corps Centers, National Guard Units, and volunteer organizations - Boy Scouts, civic and conservation groups.

Many federal agencies can supply expert advice in reclamation projects, from planning to reclamation techniques for revegetation and wildlife propagation. A few of these agencies and the types of information available are described in the following pages.

Department of Agriculture, Forest Service

The National Forest System as part of the administration of the National Forests and Grasslands has special interest and experience in the rehabilitation of surface-mined land for use as outdoor recreation, range, timber, watershed, wildlife and fish management areas. They have a long history of this type work and each year, Forest Service crews from 154 National Forests and 19 Grasslands treat and stabilize several hundred acres disturbed by mining, prospecting, and associated access roads.

Surface Environment and Mining (SEAM)

SEAM was started as a partnership with land managers, mining industry and political jurisdiction personnel at all levels. The Forest Service has the leadership and coordinating role within United States Department of Agriculture. Its function is to demonstrate new techniques in preliminary design of mining operations, new methods of rehabilitation, and new mining technologies. Environmental stewardship criteria can be simultaneously evaluated and displayed. In connection with the demonstration projects, SEAM is addressing three problem areas:

1. Quickly assembling facts so that delays in administration of mineral applications will be minimized.
2. Advancing knowledge and techniques for successfully rehabilitating mined areas.
3. Developing methods for planning mining operations in advance to harmonize eventual utilization with rural development and environmental stewardship. This includes consideration of mineral deposits as integral parts of greater economic, social, and biological entities.

Department of Defense, Army Corps of Engineers

The Corps has been studying effects of mining on navigable rivers and their tributaries. Their studies have included stream inventories, solutions to water resources problems, feasibility studies and pilot demonstration projects.

Department of Interior, Geological Survey

The activities of the Geological Survey's Water Resources Division involve basic data collection, aerial investigation of mined areas, hydrologic processes, effects of mine drainage on water quality, magnitude and extent of erosion and sedimentation by mining activities. Their reports from such studies could be utilized for planning mined land reclamation in respect to hydrologic conditions.

Department of Interior, Bureau of Land Management

For essential information on land management and planning this agency can supply many multiple use ideas. The Bureau is committed to the principles of multipurpose land uses with utilization of mineral resources being only an interim phase; not the last land use. Using a systems approach requiring physical inventory and analysis of natural resources (current and future potentials); social and economic significance and implication of the resources use, analysis of needs at local, state and federal levels; description and analysis of major alternative land use options; all organized with full public participation for the best selection and allocation of resources.

These procedures are the key framework for any reclamation project regardless of the agency or group undertaking such work.

Department of Interior, National Park Service

An agency such as the National Park Service can supply information related to reclamation of abandoned lands for specific uses, like parks and recreational areas. They are authorized to extend technical assistance in park and recreation facility planning to state and local governments.

Department of Interior, Bureau of Reclamation

Through its program activities the agency extends services to sister federal agencies, state and local governments for reclamation by restoration of fish and wildlife habitat, processes for water treatment, restoration of appropriate vegetation, watershed management and recreation facilities.

The Bureau of Reclamation's projects use many disciplines to develop their systems approach. Included are the following:

1. All aspects of onsite appraisal of the location and its geological condition, project planning including coordination and local and state participation and input of other agencies as may be needed for repayment of cost, and continued operation and maintenance of the restored area;
2. The preparation of economic analyses of the costs and benefits;
3. Preparation of typical engineering, architectural, etc., plans, and guidelines for the facilities and other work needed to restore such an area;
4. Complete construction management, from recommending standards that should be established and maintained in the building and associated construction and/or grading work to preparation of schedules showing sequences by stages of work, time, and funds required, to gathering of advanced preconstruction data, preparation, of designs and specifications, contract administration, and inspection; and
5. The establishment of designers' operating criteria, and operation and maintenance standard operating procedures.

Tennessee Valley Authority

The objective of TVA is to promote the use, conservation, and development of the nonwater resources of the Tennessee Valley and related adjoining territory; to improve the economic and social well-being of the people of the region; and to demonstrate new approaches to national development goals. Development of agricultural, forest, minerals, and environmental resources; tributary area development; regional development planning; and demonstrations in human resource development. In limited special situations, financial assistance is available to help cover administrative costs of local development programs.

Within the Tennessee Valley, officers and agencies of state, county, and municipal governments; quasi-public agencies; and private organizations, individuals, and business firms and associations may seek technical advice and assistance in general development.

Although not generally a source of direct funding for abatement projects, states within the Tennessee Valley can use this agency for technical guidance and assistance in implementing their individual pollution control programs.

Table 3-1
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS, FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Alabama	James R. Boyle P.O. Box L University, Ala. 35486 (8) 205-345-8225	
Alaska	Alfred L. Service Room G-81, Federal Bldg. Anchorage, Alaska 99501 (8) (Seattle) 206-442-0150 Ask for 907-265-4304	
Arizona	Floyd D. Everett Room 1012 2721 No. Central Ave. Phoenix, Ariz. 85004 (8) 602-261-3358	
Arkansas	Raymond B. Stroud Room 3331 Federal Office Bldg. Little Rock, Ark. 72201 (8) 501-378-5965	
California	Donald R. Irving 450 Golden Gate Ave. P.O. Box 36012 San Francisco, Calif. 94102 (8) 415-556-0640	
	William H. Kerns Room 3046 650 Capitol Mall Sacramento, Calif. 95814 (8) 916-449-2417	
Connecticut		William R. Barton SEE: New Hampshire

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS,
FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Delaware		Arnold H. Harvey SEE: Pennsylvania
Florida	John W. Sweeney Room 204 547 N. Monroe St. Tallahassee, Fla. 32301 (8) 904-377-4262	
Georgia	James D. Cooper Room 431 19 Hunter St., S.W. Atlanta, Ga. 30334 (8) 404-526-6204	
Hawaii		Donald R. Irving SEE: California
Idaho	Lawrence E. Davis Room 447, Federal Bldg. 550 W. Fort St. Boise, Idaho 83702 (8) 208-342-2678	
Illinois	Thomas C. Glover Room 1117, Ridgely Bldg. 504 E. Monroe St. Springfield, Ill. 62701 (8) 217-525-4368	
Indiana	William S. Miska Room 113 7th & College Sts. Bloomington, Ind. 47401 (80) 812-339-6139	

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS,
FEBRUARY 1, 1975

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Iowa		Joseph C. Arundale SEE: Missouri
Kansas	Harry F. Robertson Room 518, Capitol Federal Bldg. 700 Kansas Ave. Topeka, Kans. 66603 (8) 913-234-8379	
Kentucky	William T. Boyd Room 325 305 Ann St. Frankfort, Ky. 40601 (80) 502-875-4120	
Louisiana	Owen W. Jones Room 119, Federal Bldg. & Courthouse 707 Florida St. Baton Rouge, La. 70815 (8) 504-348-4374	
Maine	Robert W. Holliday Federal Bldg. Post Office 40 Western Ave. Augusta, Maine 04330 (8) 207-622-6292	
Maryland		Arnold H. Harvey SEE: Pennsylvania
Massachusetts		William R. Barton SEE: New Hampshire

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS, FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Michigan	Edward C. Peterson Room 1121, Commerce Center Bldg. 300 Capitol St. Lansing, Mich. 48933 (8) 517-372-1681	
Minnesota	Wesley A. Grosh Room G-23, Federal Bldg. Fort Snelling Twin Cities, Minn. 55111 (8) 612-725-4535	
Mississippi	Henry P. Wheeler Room 408, 301 Bldg. 301 N. Lamer St. Jackson, Miss. 39202 (8) 601-948-2510	
Missouri	Joseph C. Arundale P.O. Box 1187 Rolla, Mo. 65401 (80) 314-364-3169	
Montana	George T. Krempaskt 636 N. Logan Helena, Mont. 59601 (8) 406-442-3297	
Nebraska		Harry F. Robertson SEE: Kansas

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS, FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Nevada	Paul V. Fillo Room 306 U.S. Post Office Bldg. 705 N. Plaza St. Carson City, Nev. 89701 (80) 702-882-9380	
New Hampshire	William R. Barton P.O. Box 102 Durham, N.H. 03824 (80) 603-659-3101	
New Jersey		Arnold H. Harvey SEE: Pennsylvania
New Mexico	Joel N. Van Sant P.O. Box 1436 Socorro, N. Mex. 87801 (80) 505-835-1806	
New York	Leonard F. Heising Suite 203 1659 Central Ave. Albany, N.Y. 12205 (80) 518-869-9536	
North Carolina	Lawrence E. Shirley P.O. Box 2828 Raleigh, N.C. 27602 (8) 919-755-4166	
North Dakota	Charles A. Koch Suite 10 219 North 7th Bismarck, N. Dak. 58501 (8) 701-255-4378	

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS,
FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Ohio		William S. Miska SEE: Indiana
Oklahoma	Robert H. Arndt 168 Post Office Bldg. N.W. Third St. Oklahoma City, Okla. 73102 (8) 405-231-4521	
Oregon	Walter E. Lewis Suite 7, Standard Insurance Bldg. 475 Cottage St., N.E. Salem, Oreg. 97301 (8) 503-585-1245	
Pennsylvania	Arnold H. Harvey P.O. Box 783 Federal Square Station Harrisburg, Pa. 17108 (8) 717-782-4475	
Puerto Rico	Charles D. Hoyt c/o U.S. Geological Survey Bldg. 652 Fort Buchanan, Puerto Rico 00934 Dial 106-Ask for Overseas Operator—Puerto Rico 809-783-4660	
Rhode Island		William R. Barton SEE: New Hampshire

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS, FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
South Carolina	Herman W. Sheffer 403 Columbia Bldg. Main & Gervais Sts. Columbia, S.C. 29201	
South Dakota	M. Clair Smith P.O. Box 867 Rapid City, S. Dak. 57701 (8) 605-348-1275	
Tennessee	William D. Hardeman 401 Security Federal Bldg. 500 Union St. Nashville, Tenn. 37219 (8) 615-749-5428	
Texas	Murphy E. Hawkins Room 980, Federal Bldg. Austin, Tex. 78701 (8) 512-397-5781	
Utah	Stephen R. Wilson 1600 E. First South St. Salt Lake City, Utah 84112 (8) 801-524-5383	
Vermont		William R. Barton SEE: New Hampshire
Virginia		Lawrence E. Shirley SEE: North Carolina

Table 3-1 Continued
U. S. BUREAU OF MINES LIAISON PROGRAM OFFICERS, FEBRUARY 1, 1973

State	Liaison Officer (Office Established)	Liaison Officer (Office Responsible)
Washington	Hal J. Kelly 909 Capitol Center Bldg. Olympia, Washington 98501 (8) 206-943-7315	
West Virginia		William T. Boyd SEE: Kentucky
Wisconsin		Wesley A. Grosh SEE: Minnesota
Wyoming	Walter E. Burleson P.O. Box 1796 Cheyenne, Wyo. 82001 (8) 307-778-2481	
HEADQUARTERS OFFICE		
Washington D.C.	Richard H. Mote Chief, Liaison Program Office U.S. Bureau of Mines Room 4658, Interior Bldg. Washington, D.C. 20240 (8) 202-343-5375	

Adapted from Reference No. 81

Table 3-2
STATE LIAISON OFFICERS TO THE BUREAU OF OUTDOOR RECREATION, MARCH, 1973

ALABAMA (5)
Claude D. Kelly, Commissioner
Department of Conservation and
Natural Resources
Administrative Building
Montgomery, Alabama 36104
205-269-7221

ALASKA (1)
Theodore G. Smith, Director
Division of Parks
323 E. Fourth Avenue
Anchorage, Alaska 99501
907-279-5577

AMERICAN SAMOA (2)
Frank C. Mockler
Lt. Governor of American Samoa
Pago Pago, Tutuila
American Samoa 96920

ARIZONA (2)
Roland H. Sharer
Outdoor Recreation Coordinating
Commission
4433 N. 19th Ave., Suite 203
Phoenix, Arizona 85015

ARKANSAS (7)
Charles T. Crow, Director
Arkansas Department of Planning
Capitol Hill Building, 5th Floor
Little Rock, Arkansas 72201
501-371-1211

CALIFORNIA (2)
William Penn Mott, Jr., Director
Department of Parks & Recreation
1416 9th Street, Room 1311
Sacramento, California 95814
916-445-2358

COLORADO (3)
George T. O'Malley, Jr., Director
Division of Parks & Outdoor
Recreation
Department of Natural Resources
6060 Broadway Street
Denver, Colorado 80216
303-825-1192

CONNECTICUT (6)
Dan W. Lufkin, Commissioner
State Department of Environmental
Protection
State Office Building, Room 539
Hartford, Connecticut 06115
203-566-4667

DELAWARE (6)
David R. Keifer, Director
State Planning Office
Thomas Collins Building
530 S. DuPont Highway
Dover, Delaware 19901
302-736-1216

Table 3-2 Continued

STATE LIAISON OFFICERS TO THE BUREAU OF OUTDOOR RECREATION, MARCH, 1973

DISTRICT OF COLUMBIA (6)
Joseph H. Cole, Director
D.C. Recreation Department
3149 - 16th Street, N.W.
Washington, D.C. 20010
202-628-6000

FLORIDA (5)
Ney C. Landrum, Director
Divison of Recreation & Parks
Department of Natural Resources
J. Edwin Larson Building
Tallahassee, Florida 32304
904-488-6131

GEORGIA (5)
Joe D. Tanner, Commissioner
State Dept. of Natural Resources
270 Washington Street, S.W.
Atlanta, Georgia 30334
404-656-3500

GUAM (2)
Gerald S. A. Perez, Director
of Land Management and
Executive Secretary for the
Territorial Planning Commission
Territory of Guam
Agana, Guam 96910

HAWAII (2)
Shelly M. Mark (Dr.) Director
Department of Planning and Economic
Development
State Capitol
Honolulu, Hawaii 96813

IDAHO (1)
Steven W. Bly, Director
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Table 3-2 Continued

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Table 3-2 Continued

STATE LIAISON OFFICERS TO THE BUREAU OF OUTDOOR RECREATION, MARCH, 1973

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Table 3-2 Continued
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Table 3-2 Continued

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Adapted from Reference No. 81

CHAPTER 4

TECHNICAL APPROACH

TECHNICAL APPROACH

The objective of the administering state agency in an abandoned mined lands program is management of the state's total resources, which involves abatement of water pollution and restoration of the land. In order to successfully complete such a comprehensive program, a systematic and logical approach must be utilized. The exact method a state employs will depend on variables such as: financial resources; magnitude and diversity of the state's problem; staff size of the administering agency; and socio-economic needs of the state's residents. Since this document is designed as a general guide for many users, each step in the mined land inventory, data evaluation, and abatement and reclamation implementation process is presented with alternative methods or options which relate to the specific requirements and subsequent level of effort assigned to the project. Thus, regardless of the variables, one of the alternative or optional methods discussed in each procedural step can supply some degree of information. For maximum efficiency, it is essential to define as many variables as possible at the start of the program and to determine the degree of detail necessary to accomplish program objectives. This will increase the usefulness of data and accuracy of evaluation, while reducing financial and manpower waste associated with collection of interesting but unusable information.

An area-wide mined lands inventory will assess and document past pollution abatement and restoration efforts, and provide a sound basis from which to establish future program planning and priorities. In addition to summarizing and updating state mining information, it also places the state in an advantageous position to apply for and receive financial and technical assistance from federal sources.

A successful mine drainage abatement and mined land reclamation program should be comprised of the following inter-related steps:

1. Development of base mapping;
2. Watershed definition;
3. Water quality survey;
4. Socio-economic survey;
5. Mined lands survey;
6. Reclamation and abatement cost development;

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7. Priority establishment;
8. Final map development.

Each aspect of such a long range reclamation and pollution abatement program will be discussed in subsequent sections. A number of optional approaches are presented in each discussion, along with approximate costs where applicable. It must again be emphasized that selection of the appropriate option or approach must be determined on an individual study level, depending upon such factors as funding availability, size of study area, intensity of mining within that study area, size of and distance between individual minesites, and the extractive industry in question.

DEVELOPMENT OF BASE MAPPING

Identification of the state's major problem areas must be completed before detailed aerial mapping is started. This reduces the aerial photography cost by concentrating low level photos on areas affected by mining. Major mine site identification can be accomplished using one of the following options which are listed in order of increasing level of effort.

1. Identification using existing data in the form of mining records, water quality data, reclamation records, or mining permits. This data is commonly available free or for only the cost of reproduction of the information.

2. Use of existing large scale aerial photography from previous studies, the Soil Conservation Service (SCS), Earth Resources Technology Satellite (ERTS), U-2 flights, or other sources. Costs are minimal for all of these - SCS charges for photo reproduction only ERTS charges $4.00 per 259 sq. km. (100 sq. mi.), U-2 photos cost $8.50 per 259 sq. km. SCS photos are often out-dated (as relates to this study), and other high level photos have limited resolution capabilities and often cannot be enlarged to a satisfactory scale. (Imagery taken after January, 1975, by NASA utilized Land and Satellite 2 and can be obtained in similar manner as ERTS).

The option chosen will depend primarily on availability of existing information (required for option 1) plus manpower resources required to collate and plot the information. The information obtained should then be incorporated into the working base maps.

Development of working base mapping for the study should be completed early in the study. This base mapping may be the large scale photos previously mentioned, but it is more advantageous to acquire topographic base mapping. An excellent source of such maps is the United States Geological Survey, which has available 1:250,000 scale mapping. USGS can provide overlays of the various features printed on those topographic maps, enabling development of a base map specifically suited to needs of the project. Utilizing these overlays, specific map features or colors can be emphasized, de-emphasized or totally eliminated as desired. Streams can be given emphasis on the base maps, while planimetric features such as roads and towns, which are important in locating specific areas, can remain unchanged. Certain features which are not required to achieve goals or depict results of the specific segment of the project (such as locations of forested areas and the topographic contours), can be de-emphasized or totally eliminated from the water quality maps. The alteration of USGS maps results in a base map (or maps) ideally suited for displaying the specific information obtained or utilized to achieve the project goals.

Figures 4-1 and 4-2 show two segments of typical 1:250,000 scale USGS mapping that would be utilized either individually or in composite form as base mapping for a statewide or regional study. Figure 4-1 shows a composite of two map overlays available from USGS, culture (roads, towns and political boundaries) and topography. Figure 4-2 shows a third overlay, major streams, which is also available from USGS. Various combinations of USGS overlays are frequently desirable for different aspects of preliminary base mapping, such as plotting of existing background data, study area breakdown, establishment of primary stream sampling networks, and determination of geographic priority areas for the study. The stream overlay above may be best suited for plotting stream flow measurement and sampling points, and water quality or flow data from previously completed studies. This overlay is also well suited for preliminary, general delineation of individual watershed study units or modules.

The overlay containing topographic contours also has potential

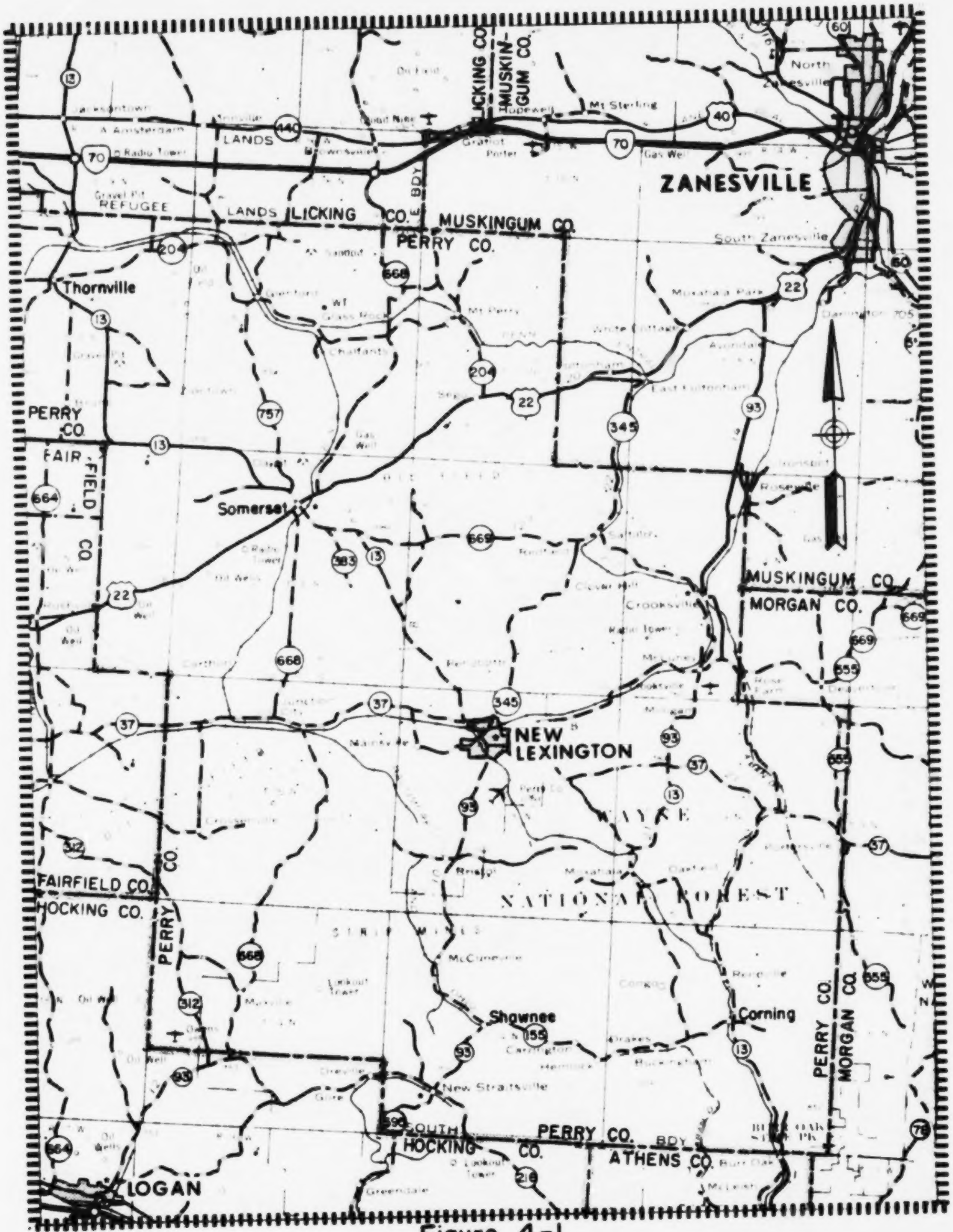
ZANESVILLE
NEW LEXINGTON
Somerset
Thornville
LOGAN
Shawnee
Corning
New Straitsville
South Zanesville
North Zanesville
LICKING CO.
MUSKINGUM CO.
PERRY CO.
FAIRFIELD CO.
HOCKING CO.
MORGAN CO.
ATHENS CO.
WAYNE
NATIONAL FOREST
STRIP MINES
Crooksville
Roseville
Junction City
Hopewell
Mt Sterling
Brownsville
Gratiot
Glenford
Chalfants
Mt Perry
Rendville
Hemlock
Buckingham
Burr Oak
70
40
22
13
37
93
345
204
668
669
555
155
312
664
757
383
216
595
146
60
78

Figure 4-1

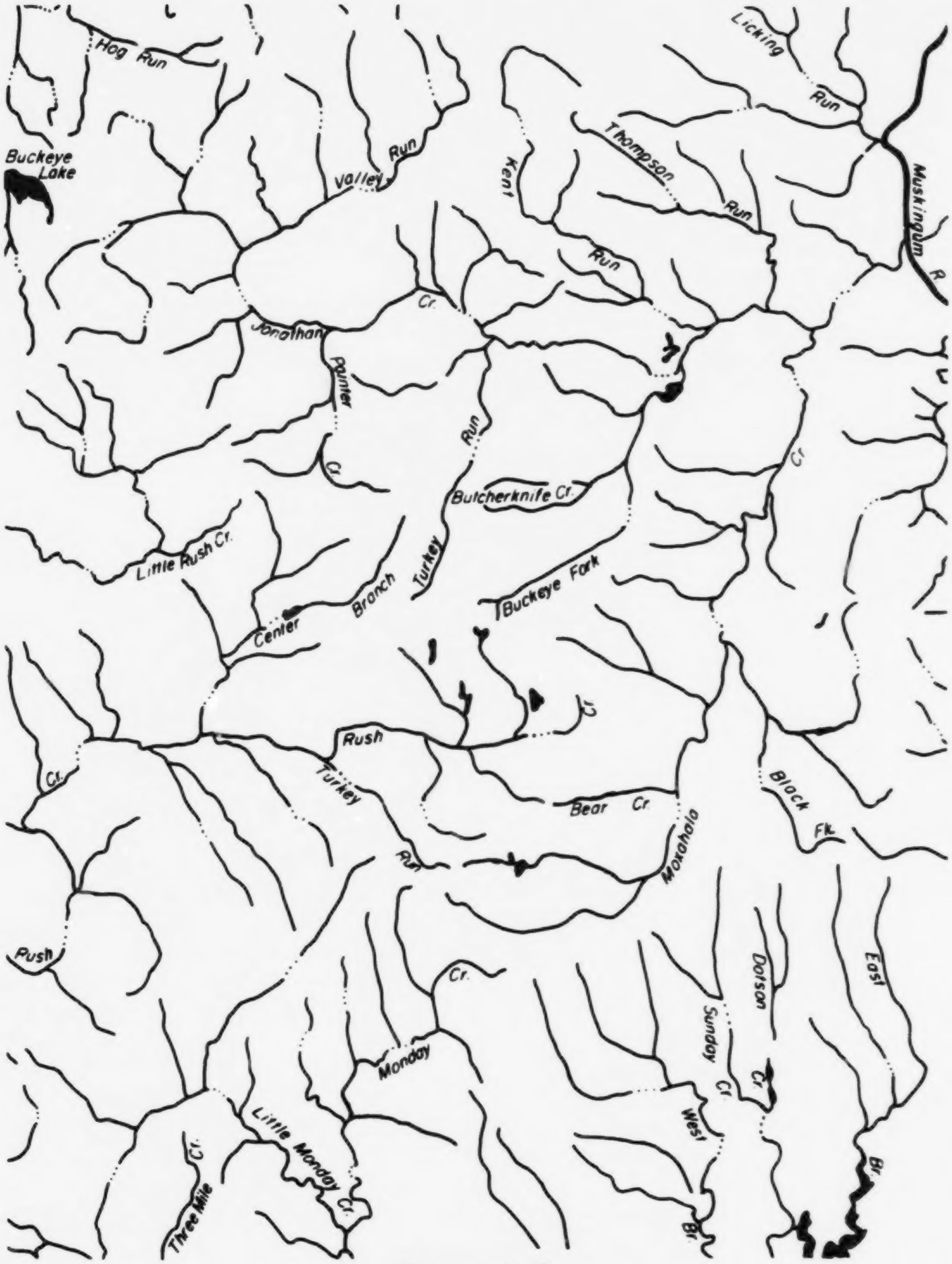
Hog Run
Licking
Run
Buckeye
Lake
Valley
Run
Kent
Thompson
Run
Muskingum
R.
Run
Cr.
Jonathan
Painter
Cr.
Run
Butcherknife Cr.
Cr.
Little Rush Cr.
Turkey
Branch
Center
Buckeye Fork
Cr.
Rush
Cr.
Turkey
Bear Cr.
Black
Fk.
Moxahala
Run
Rush
Cr.
Monday
Dotson
East
Sunday
Cr.
Cr.
West
Little Monday
Cr.
Cr.
Three Mile
Br.
Br.

Figure 4-2.

uses early in a study. These overlays can be utilized alone or in composite form with the stream overlay for more precise delineation of sub-watershed units or modules along actual watershed and topographic divides. Since it is desirable to use topography and watershed divides as a basis for such a study area breakdown, the local culture from the third map overlay is not used until the study area breakdown has been completed. Once this breakdown is complete and the establishment of a water sampling or mined land visitation program is initiated, major access routes become a primary consideration, and the need for topography on the preliminary base mapping declines. At this time it may be advantageous to utilize a preliminary base map consisting of only streams and culture, with topographic contours eliminated. This often produces a much more easily readable map, particularly in steep terrain areas where the large number of topographic contours can tend to clutter the mapping.

For final presentation of study data, it may be desirable to develop a composite of all three of these overlays - culture, streams, and topography - with one or more of the features highlighted for ease of reading. For example, streams and culture are generally deemed most important and are both clearly shown. Topography may be less important for map presentation of data, but may still be useful at certain times; therefore, it can be included at a reduced intensity similar to a background on the map.

Depending on size of the study area and volume and detail of data to be presented, it may also be possible to enlarge the 1:250,000 scale USGS sheets and overlays to a more suitable scale such as 1:125,000. Such enlargements are not illustrated here because, except for the scale, they would be identical to the 1:250,000 mapping shown. In some states or regions, there may also be other scales and types of suitable base mapping more readily or economically obtainable. Such mapping should be utilized when possible to reduce costs of base map development.

Two sets of working base maps at different scales - one for detailed, specific, precise data presentation and one for more general, summary data display, can be very helpful. Use of such dual mapping scales can be beneficial in initial mapping of existing water quality data, delineation of working watershed units or modules, establishment of new sample and flow collection stations, and actual field work required for the study. Possibilities for these working base maps include:

1. State Department of Transportation or Department of Highways County Highway Maps (scale will vary in different states);
2. The previously described USGS 1:250,000 scale mapping enlarged to a suitable scale such as 1:125,000; and
3. USGS 7.5 minute topographic quadrangles (scale 1 cm. = 240 m.).

These working base maps are well suited to relatively large study areas because they contain sufficient detail for accurate mapping or data plotting in most situations. However, where the study area is extremely small or widely scattered, it may be beneficial to select some different base mapping scale that would allow even more detailed presentation and analysis of data.

WATERSHED DEFINITION

Verification and supplementation of historical records and aerial surveillance with ground surveillance should be undertaken on a watershed basis. The watershed sampling survey's objective is to supply additional data to the administering agency to establish accurate land inventory records needed to develop abatement and reclamation plans.

In order to develop comprehensive plans, detailed information is needed on water quality, aquatic ecology, terrestrial impact, reclamation potential, land use potential and socio-economic area needs. These factors are interrelated and jointly affect a geographic area, usually in the form of a topographically defined watershed rather than a politically defined area (town, city, township or county). This is true because mining and resultant pollution follow topographic, not political boundaries. It is, therefore, reasonable to develop surveys and evaluate their data by watersheds.

Prior to any actual field work, size of the watershed modules to be studied should be determined. This determination will depend on a number of variables such as:

1. Previous indications of general water quality within various watersheds.
2. Diversity and distribution of the abandoned mined lands.
3. Amount of available inventory funds and manpower.
4. Quantity and accuracy of detail of the data necessary to meet program objectives.

Established watershed modules should be used for all phases of ground surveillance including the water quality survey, terrestrial survey, reclamation survey and socio-economic survey.

A number of different systems are available for delineating watershed modules.

1. Logical delineation after assessment of existing water quality data, mining data, topography, and watershed size.
2. Random selection from topographic map inspection.
3. Selection using EPA STORET stream classification system.
4. Selection using Horton stream classification.

Each of these options has obvious advantages and disadvantages, and the method which best serves any one agency will depend primarily on total area to be surveyed and complexity of the problem. However, a short description of each system may be useful in deciding which is most useful in a particular situation.

Watersheds established along logical topographic divisions will be of fairly random size and shape. This offers the possibility of intentionally altering the size in areas of known mine concentrations. In such areas of high known mining or water pollution concentration, modules can intentionally be kept smaller to permit more detailed study and assessment. Experience has shown that watersheds ranging in size from 130 to 1,040 square kilometers (50 to 400 square miles) in areas of relatively concentrated mining are ideal working units.

The use of the EPA STORET stream classification system has initial appeal, primarily due to its extensive coverage and associated water quality data. EPA uses a hydrologic stream classification system to identify locations of sampling points. This hydrologic index, or River Mile Index (RMI), is a numerical code which identifies the location of a point on a defined river system by its hydrologic relationship to the river system and its distance upstream from the mouth of the river. The following six codes comprise the complete index:

1. A two-digit major basin code
2. A two-digit minor basin code
3. A three-digit terminal stream number
4. Indices which define direction and level (ranking) of stream flow
5. Mileages which define distances between and to confluences in the river system
6. Code defining the stream level (rank) on which a point is located

During the past several years, EPA has been engaged in assigning index (codes) to stream systems throughout the Nation. Codings were recorded on USGS 7.5' topographic maps and are available from STORET Operations and EPA regional offices. By obtaining STORET codings for streams within their states, state agencies can obtain any available information on water quality parameters for any desired stream.

Horton's stream classification was developed as part of a monographic study in hydrology. The scheme has been modified and popularized by authors such as Strahler, Leopold and Marchand, and it has become established most strongly in studies of watershed geomorphology. The classification is based on the simple observation that streams consistently bifurcate in such a way that they can be ranked numerically. Headwater tributaries with no antecedents are designated 1st order; union of two such units forms a 2nd order stream; union of two 2nd order streams forms a 3rd; etc. Rank is not increased when a stream receives tributaries of lower order than its own. First order streams can normally be expected to have a basin size in excess of 1 km^2. The world's largest rivers are 10th order. Although there are great differences between streams in many of their characteristics, there is also amazing consistency among streams with regard to certain parameters.

The Horton system offers the following advantages:

1. Uniformity of watersheds once a stream order is determined
2. Accuracy of determining manpower needs for each watershed survey
3. Predictability of the quantity of detailed information from each survey
4. Reliability of comparing one watershed with another (working from a standardized base)

If the Horton's system is chosen the agency has a series of options in determining the actual size of watershed.

Watershed Size Options

1. Individual mine complex
2. Horton's 2nd order stream - approximately 13 square kilometers (5 square miles) watershed
3. 3rd - 4th order streams - watershed size of 52 to 260 square kilometers (20 to 100 square miles)
4. 4th order streams - watershed size of 1,295 square kilometers (500 square miles)

Experience has shown a watershed of 130 to 260 square kilometers (50 to 100 square miles) that is 3rd or 4th order streams is often ideal size for routine ground surveillance.

WATER QUALITY SURVEY

Water quality evaluations in statewide abatement assessment should consist of two distinct phases:

1. Collection, mapping and analysis of existing water quality and streamflow data; and
2. Establishment of new or repeat sample collection and flow measurement stations with subsequent sampling and data evaluation.

Assess Existing Data

Evaluation of existing data can be initiated by identifying and contacting all potential sources of information relevant to the project. Water quality data from past studies and sampling programs can be obtained from many of the following sources:

- U. S. Environmental Protection Agency's computerized STORET system,
- U. S. EPA's Source Investigation Surveys, conducted to locate and identify point sources of pollution and to delineate mined lands in various watersheds throughout the Nation,
- Watershed surveys conducted by the former Federal Water Pollution Control Administration,
- Records from the U. S. Geological Survey's stream gauging stations,
- State agencies or departments concerned with environmental protection, natural resources, health, streams, water quality, forestry or fisheries,
- Agencies established throughout the Nation solely for the management of specific watersheds or river basins, such as the Ohio River Basin Sanitation Commission (ORSANCO), The Interstate Commission on the Potomac River Basin (INCOPOT), the Susquehanna River Basin Commission (SRBC), the Yellowstone Basin Water Users Association, and the Powder River Basin Resource Council.

These and other similar data sources may provide important stream-flow data on pertinent mine drainage parameters such as pH, net acidity or alkalinity, specific metals, sulfates, turbidity, total suspended solids, dissolved oxygen, and specific conductivity. This data is vital in determining general water quality trends and major source areas of mine drainage pollution, and can help to narrow down subsequent stream sampling efforts to areas in which data gaps exist.

Mapping of this water quality data can be initiated by renumbering the data points using a single, logical numbering system keyed to the original source of information and the specific data point within that source. All existing water quality data can then be plotted on working base maps. Poor mapping and sample point location descriptions in sources of existing data occasionally hamper plotting of some sample points, but data can usually be replotted with a fair degree of accuracy. To simplify interpretation and assessment of existing data at these sample points, corresponding chemical analyses and stream flow data from each source can be keyed to the newly assigned numbering system, tabulated and listed by watershed. This greatly simplifies the process of locating sample points and associated water quality and flow data available from previous studies.

Establish Sampling Program

Regardless of the parameters of importance in the specific study area, survey planning, sample point location, sampling techniques and monitoring frequency are all approached in a similar manner. Sampling program planning should be based on quantity of additional data needed and can be established on working prints of the previously discussed base mapping. The number of sampling stations per watershed depends on watershed size and historical indications of water quality. Mining stations can be located at or near road bridges to minimize time involved in locating stations and obtaining field measurements. The working field maps, with all sampling points plotted and numbered, can then be divided into workable "clusters" or groups of maps on a watershed basis, and assigned to a field sampling crew.

Field data sheets should be developed to facilitate simple, rapid notation of stream conditions and characteristics at each sample location. These field data sheets are completed for every station sampled and, as a minimum, should contain the following information: samplers' names, date of sample collection and flow measurement; sample station number; sample location by stream name, watershed, coordinates, county, township, range and section; stream flow conditions - high, medium or low; presence and extent of any pollution indicators, such as iron staining on the stream bed (a positive indicator of the presence of acid mine drainage); water discolorations; presence of suspended solids; siltation of the stream bottom; evidence of animal or plant life in the stream; field pH of the water; and the number, administering agency and stage height of any flow gauging stations at the sample sites. The field sheets can also contain space for recording sample chemical analyses reported by the laboratory, and stream pollution loadings later computed by office personnel.

Stream sampling field crews must be instructed in the water sampling and stream flow measuring techniques to be utilized prior to initiation of a field program. The field techniques should enable sampling crews to gather water quality or ecological and flow data that gives the best degree of accuracy for the time and funds available.

Determine Stream Survey Parameters

Survey parameters assessed - sampling frequency, techniques, and location - will all depend upon the requirements of each individual study. Funding availability, study area size, time constraints and nature of contaminants or pollutants attributed to the specific extractive industry will all play an important role in selecting biological, chemical, and physical analysis parameters. Several options exist for parameter selection, sampling frequency, sampling technique, and sample point location. Considerations assessed are sub-divided into major divisions which are further divided into options. Various combinations of analysis parameters and options would then represent increasing levels of study intensity or effort as described. Parameters, options, and approximate costs are listed below.

Chemical Parameter Options

Chemical properties of streams within study areas must be analyzed to determine the presence of pollutants attributable to mining. Parameters selected for analysis should be those known to be related to the extractive industry or those key chemical constituent concentrations required to assess the presence and extent of stream pollution. Government analysis rates from recent chemical analysis price lists are presented below for the mine drainage constituents most commonly present in various mine drainages. Based on these costs, stream chemical analyses could range from a few to $40 or $50 per sample, depending upon the number of parameters analyzed.

Parameter	Cost
pH	$0.75
Acidity, hot	2.75
Acidity, cold	1.75
Alkalinity	1.75
Specific Conductance	1.50
Dissolved Oxygen	2.75
Turbidity	1.50
Total Suspended Solids	2.25
Sulfates	3.10
Metals (by Atomic Absorption)	2.75 to 3.50 each

Physical Measurement Options

Information on the physical configurations of stream channels and their flows at sample stations is necessary for computation of pollution loadings, and can be obtained simultaneously with the acquisition of stream samples. Five options for stream flow and velocity measurement, ranging from minimum to maximum level of effort, are presented with approximate costs below:

1. Estimate based upon watershed drainage area. No cost.

2. Estimate based upon previous flow data. No cost.

3. Rapid cross-sectional measurement (width and average depth) and velocity (floating chip and stopwatch method). Cost = $35 per station.

4. Detailed cross-sectional measurement (surveyed section) and velocity (floating chip or Gurley meter). Cost = $60 per station for first sample, $25 per station for subsequent samples at same surveyed station.

5. Detailed transect with velocity profiles and bathymetry. Cost - $100 per station.

Bottom sediment measurement and coring may also be desirable during acquisition of physical data at sampling points particularly in very detailed studies. The cost of analysis of this sample is about $25.

Biological Parameter Options

These parameters are generally only assessed in more detailed studies, where funding is abundant or where the study area is relatively small. Biological factors would also be analyzed in subsequent, more detailed watershed feasibility studies.

Use of monitoring biological organisms such as benthic macroinvertebrates or fish may prove to be helpful in monitoring pollution levels in mining areas where discharges are intermittent and/or sublethal in concentration. These organism populations' community structure and community diversity index reflect long term integrated and accumulated effects. Thus, they can offer better indications of environmental impact than just grab chemical and physical data. However, biological sampling is more expensive and time consuming to collect and evaluate. Two biological parameters are discussed here, but in typical detailed biological sampling, both would be assessed. Costs for these analyses are relatively high, but since biological conditions generally represent long rather than short term water quality, sample frequency is much less than that for chemical parameters.

Benthic sampling consists of dredge samples (deeper streams) or Surber samples (small streams) plus taxonomic identifications of stream benthos, or bottom-dwelling organisms. Six samples are required along a transect at each stream station. Cost of sampling and analysis is $50 per sample or $300 per stream transect.

Assessment of fish life in each stream requires a fishery inventory, associated laboratory analysis, and subsequent data evaluation. Each "sample" consists of analysis of approximately 450 square meters of stream area. Samples can be taken above and below the confluence of each major stream. For example, one sample could be taken at the mouth of each watershed or module and one on the mainstream just below that stream mouth. Cost of each fish analysis or sample is $500.

Sampling Frequency Options

Sampling frequency options are determined by size of the study area, time available, and funding. These factors must be assessed for each individual study to determine the frequency of sampling, and a program must be established to permit maximum acquisition of relevant data within study time constraints. Typical sampling frequency options are listed below in order of increasing time and cost requirements:

1. One-time-only sampling with adjustment factors for yearly average stream discharge volumes and chemical loadings.
2. Quarterly sampling to determine seasonal conditions.
3. Monthly sampling of all chemical and biological parameters.
4. Continuous monitoring of chemical and physical parameters and monthly biological sampling.

Sample Location Options

Here again, time and funding constraints play an important role in determining the number and locations of sample points. Sample breakdowns in typical large scale statewide abatement will generally average about 30 stations per hundred sq. km. of study area. Where limitations must be applied to the sampling program for some reason, this number can be reduced to a base minimum of one sample point at the mouth of each watershed area or module. Where greater levels of detail are desired - in heavily funded studies and studies covering relatively small mined land areas - individual mine discharges and minor tributary streams can be sampled to obtain an even more accurate picture of water quality conditions within the study areas.

Typical Stream Survey Program

For a typical mined land inventory program with reasonable financial support and diverse, relatively constant mine drainage problems, the following choice of alternatives for the stream sampling program would be practical:

1. Chemical parameters as required to assess general presence, absence and severity of mine drainage pollutants.

2. Rapid cross-sectional stream channel measurements with floating chip and stopwatch velocity measurements.

3. No biological sampling.

4. One-time-only samples and flow measurements with flow adjustments to represent seasonal averages. Time permitting, quarterly sampling would be even more desirable.

5. Systematically divide study area into watersheds or modules. Sample streams at mouths of these modules and major tributaries to those streams (also at mouths).

If the suggested options are utilized, a program may resemble the following survey. Water samples and flows may be taken on a one-time-only basis, except for the mouth of significant major streams or tributaries within each watershed. These points may be sampled more often, the number of times depending on amount of water quality data desired. Average widths and depths are measured where possible, and estimated where measurements are extremely difficult to obtain. Velocities are measured at various points across each stream using an electronic flow meter (such as a standard "Gurley Meter") or the floating object ("chip") and stopwatch method. Stream conditions at the time of sampling are carefully noted; pH's, specific conductance, dissolved oxygen are taken, and water samples are collected for later chemical analyses.

A fast, simple and fairly dependable method of determining stream flows involving stream cross-sectional areas and average water velocities can be utilized for a study. This involves sample crews wading into streams where possible to measure depths at numerous intervals across the streams. Measurements can sometimes be made from bridges with a weighted line on large streams that are too deep to wade. Stream depths are taken, averaged, and the average depth value is multiplied by the measured stream width to obtain a stream cross-sectional area.

When the floating chip method is used, measured stream velocities are reduced by 20% to account for the higher than average velocity that occurs in the surface water layer of the stream. Adjusted velocities and cross-sectional areas are then utilized to compute preliminary stream discharge, which is placed on the field data sheets.

Previous experiences with one-time-only grab sampling programs similar to the one described have shown that the minimal amount of water quality and stream flow data generated by such programs does not give accurate indications of yearly flow and water quality conditions. Data of this type is necessary to gain a complete understanding of the true overall water quality and flow conditions, particularly in polluted streams.

Water quality and flow data obtained from frequently or continuously monitored sample and flow measuring stations (for example, in the Appalachian Coal Fields) have revealed certain characteristics common to many drainage areas within specific watershed basins. Flows in most streams in Appalachia exceed the yearly average flow rate during only about one quarter of the year, mainly because half of a stream's total yearly flow passes any given point along that stream within the first three and one half months of the year. Flows then generally average 20 to 30 percent below the yearly average during the summer months. Similar relationships may exist for other areas of the United States; such relationships should be defined and used to adjust periodic flow measurements to yearly average values.

In areas affected by acid mine drainage it also appears that slugging is a significant factor in a watershed's mine drainage pollutant production capability. In many such streams, increased flow after high rainfall periods is accompanied by an increase in concentration of pollutants from refuse dumps, mine spoil banks and some underground mines. Therefore, high rainfall does not necessarily improve stream quality through dilution in areas of mine pollutant production. Instead, concentrations of mine pollutants many times remain constant or increase during high flow periods, resulting in higher pollution loadings. This could be supported by the fact that fish kills attributed to mine drainage frequently occur during or immediately following heavy rainstorms.

Based on these findings, stream flows within the study area can be adjusted to represent yearly averages without severely misrepresenting relative pollutant loads or water quality. All flows obtained can thus be adjusted to represent yearly averages, utilizing daily recorded flows at several continuously monitored United States Geological Survey stream gauging stations within the state.

To accomplish this task, designated watersheds within a study area must be broken into groups, each represented by a different USGS stream gauging station. Daily flow records are obtained for each of these USGS stations for the period during which the sampling programs are conducted. Recorded stream flow for any given day is then divided by the recording station's average flow to yield a flow constant applicable to all flow measurements taken on that day in the watersheds represented by the gauging station. These calculations will yield sets of constants - one set for each group of watersheds. Each set contains a separate constant for each day of the study period, and that constant reflects the relationship between the flow on that day and the average yearly stream flow in that area.

Using these constants, all measured flows obtained during the study are adjusted to represent yearly average flows. If the flow adjustment constant is less than 1.0 (every day in which the gauged flow was greater than the yearly average flow), then flows measured on such days should be adjusted downward. A flow constant greater than 1.0 (whenever daily gauged flows are less than the yearly average) would mean that all flows measured on these days should increase accordingly. This subsequently enables stream pollution loadings to be adjusted to represent yearly average values.

It is possible to estimate on a gross basis the costs that would be incurred by a statewide abatement water quality survey of intermediate difficulty level, such as the one just described, or of higher or lower levels of detail. Statewide programs covering relatively large areas and similar in detail to the one described in this section would cost about $4.00 per square kilometer ($10 per square mile) to complete. If funds are limited and the water quality survey must be limited to the collection and analysis of already existing data, the cost of this water quality survey can be reduced to about $.77 per square kilometer ($2.00 per square mile). A full scale, in-depth water quality study with extensive sampling of many physical and biological parameters and detailed flow measurements could cost approximately $116 per square kilometer ($300 per square mile) of study area.

SOCIO-ECONOMIC SURVEY

A statewide pollution abatement and mine restoration program must encompass an assessment of an area's economic needs and developmental demands in establishing watershed ranking and reclamation priorities. Restoration programs may not be undertaken strictly for aesthetic environmental improvements, but can also attempt to improve utilization of local or regional water and land resources for the general public. Subsequent stimulation of an area's economy and other beneficial effects of such programs thus enhance general well-being of the citizenry.

Collection and analyses of socio-economic information may be accomplished utilizing any of a number of options, depending primarily on availability of state human resource data, economic needs, development demands and aesthetic interest of the citizenry. In areas where planning organizations are well developed at local levels, socio-economic information will be adequately documented and easy to assemble. However, not all states or areas will be lucky enough to be in this situation, and alternative mechanisms must also be considered. To accomplish the objectives of a statewide abandoned mined lands program, the following socio-economic components must be considered:

1. Human resources;
2. Economic needs;

3. Development demands and;
4. Aesthetics.

The level and intensity of investigation can vary with the individual state program objectives and priorities.

Several optional socio-economic data collection techniques are available. By increasing levels of effort required, these are:

1. Utilization of data from existing sources, such as census bureaus, planning agencies, and environmental action groups.

2. Initiation of a polling survey to identify public opinion concerning watershed economic needs, development demands and views on aesthetics, and to collect other pertinent data from available sources.

    a. Polls conducted by telephone interviews or mailed questionnaires.
    b. Conduct personal interviews at the local level.

A combination of the above options may be necessary because of the diversity of conditions throughout various states.

In order to reduce subjectivity of this information, during the analysis and evaluation phase, the data could be quantified and incorporated into a numerical evaluation system. One such system involves the establishment of evaluating criteria and numerical ranking as shown in Table 4-1.

The numerical watershed ranking system can then be incorporated into the reclamation priority establishment system by assigning a coefficient. This coefficient can be multiplied by the rating value to provide overall statewide priorities. The coefficient value should reflect the total program criteria and objectives.

Characterization of socio-economic conditions, as previously mentioned, should include evaluation of human resources (population, density, immigration and emigration rates, labor force and employ-

Table 4-1
SOCIO-ECONOMIC RANKING SYSTEM

Parameter	Criteria	Watershed Ranking
Human Resources	Urban Population 5,000 or greater	1. High Density 2. Presence 3. Close Proximity 4. None
Economic Need	Poverty Level	1. High Percentage 2. Medium 3. Low 4. None
Development Demand	Proximity to or Presences of Major Roads, Airports, Recreational Facilities	1. High Level 2. Medium 3. Low 4. None
Aesthetics	Public Visibility	1. High 2. Medium 3. Low 4. None
	Visual Quality	1. Highly Intrusive 2. Medium 3. Low 4. None
Current Land Uses and Values	Financial Value of Reclamation	1. High 2. Medium 3. Low 4. None

ment diversity), economic needs (current land use and value, transportation and tax base), development demands (area needs and subjective pressure), resource ownership, and aesthetics (public visibility and visual quality). The importance of any one of these factors will vary according to the specific nature of each statewide abatement study; however, establishment and use of a weighing system will insure that locally significant factors receive appropriate attention in developing reclamation priorities. A number of relevant socio-economic factors are discussed in subsequent portions of this section.

Human Resources and Economic Needs

The economic and social stability of an area, whether it is a state, county or watershed, is directly affected by population density, immigration and emigration rates, and employment diversity. The principal effects of these factors are on the local tax base (personal head tax, municipal wage tax, school tax, property tax and income tax). For example, an area with low population density, a monotypic occupational structure, and an emigration rate higher than its immigration rate is characterized by declining population, diminishing tax base, and reduced employment opportunities. Such a community cannot improve without some type of economic stimulus to alter population trends and employment opportunities, and subsequently improve the tax base. One such economic stimulus could be restoration of abandoned mined lands to conform to specific developmental needs of the area, such as improved tourism through creation of recreational facilities, or development of needed home sites, industrial parks or agricultural lands.

One means of measuring the economic need of an area is assessment of the percentage of families whose income is below poverty level, which can be broken down by watershed or political boundaries. The Bureau of the Census, U. S. Department of Commerce, is an excellent source of such information. Poverty thresholds are defined by the census according to head of household, age, number of children, and whether or not the family lives on a farm. Since data to be utilized in this analysis is usually coordinated by township, it can be beneficial to convert census information to coincide with the established watershed boundaries.

Current Land Uses and Values

The fair market value of abandoned or reclaimed mined lands is controlled largely by inflational increases and potential land use benefits which govern selling prices and tax benefit values. A number of economic and environmental, or physical factors can also make a positive contribution to land values. These factors include proximity of the mined lands to population centers and transportation networks, favorable topography and physical site characteristics, easy access, and availability of utilities. Difference in sale price between unreclaimed and reclaimed mined lands is also influenced by value and use of adjoining land and presence or absence of a water supply with acceptable quality. More specific information concerning interrelationships of land use, value and reclamation potential see Section I, Chapter 3 of this report.

Development Demand

Development demands are tied directly to economic needs of an area. The demand variable is comprised of a number of distinct elements. These include access, proximity to urban areas, recreation resources, and availability of air transportation. Access can be defined in terms of available interstate highways or major U. S. routes within a watershed or close enough to serve the needs of the watershed. The urban area element can be determined by presence or absence of an urban area with a population of at least 5,000 persons in or closely adjacent to the watershed. Recreation resources are generally designated by the States as those areas having the highest potential for development as recreation facilities. Watersheds containing a recreation resource will likely benefit more from reclamation efforts, especially if the unreclaimed mined land is within the area designated for future recreation expansion. The last element, airports, can be an extremely important factor in determination of reclamation goals for mined lands. Benefits to communities near airports can be substantial. In many cases, presence of the airport can stimulate other activities within the immediate area, such as industrial, commercial, recreational, or community service development. Thus, those watersheds with airports or potential airport sites are deemed to have a high demand for reclamation and abatement work.

Developmental demands may be objectively evaluated by a straight-forward weighting system utilizing overlay maps depicting the major highway network, urban areas, recreation resources, airports, and watershed boundaries. Each watershed is then rated according to presence of these features, and assignment of weighting coefficients is determined by the program administering agency based on its statewide developmental criteria.

Ultimate land use plans depend greatly on the ability of planners to anticipate the direction and magnitude of economic needs and resultant development demands. Planners must channel and encourage growth through development and utilization of all available resources. This development may simply be an enhancement of the intangible aspect of the environment in the form of improved aesthetics. It is difficult to establish a direct link between economic needs, development demands, and improvement of aesthetics; however, an aesthetically pleasing environment tends to have a greater potential for development and economic stability.

Aesthetics

Aesthetic values are by far the most subjective of socio-economic characteristics evaluated in developing watershed ranking and reclamation priorities. The aesthetic impact of an area may be determined by assessing two components - public visibility and visual quality.

In order to be aesthetically displeasing, an area must first be visible to either local residents or transients - visitors and tourists. The significance of public visibility can be assessed and ranked by proximity of the unreclaimed land to highways, railways, waterways and towns combined with the number of people using these facilities. Once the public visibility has been quantified, its impact can be assessed by determination of stream or landscape visual quality.

Visual quality can be based on visual intrusion of aesthetically displeasing forms such as abandoned equipment and structures, vast unvegetated and eroded expanses of terrain, and heavily silted or polluted streams. Restoration priorities should at least consider the premise that areas with high visual intrusion receive higher priority. Visual quality may also be equated with landscape diversity, the amount of variety and interest generated by distribution and combination of landscape components - landform, landscape pattern, water, vegetation, and existing land use. A more diverse or heterogeneous landscape generally has a higher visual quality. This method of visual quality analysis has been successfully employed in many recent environmental analysis studies.

The final watershed ranking based on aesthetics can be determined by combining the results of the public visibility and visual quality assessments and applying weighting coefficients.

MINED LANDS INVENTORY

The primary objective of a mined lands inventory is systematic and logical acquisition of information for characterization, ranking and establishment of statewide long range plans for restoration of abandoned mined land. Inventory of this land can be accomplished in a number of ways.

Depending upon the scope of a state's abatement program and the time and funds available, there are a number of parameters which can be assessed in varying levels of detail. Biological assessments can include types of vegetation and percentage of cover, which can be obtained by either visual inspection or use of conventional photographs. Physical considerations include slope of spoil piles, extent of regrading completed, presence of outstanding surface features such as buildings, ponds, highwalls, and refuse areas, and extent of erosion. Physical data measurement may include vertical and horizontal distances, slopes, and areas. These can be either estimated from stereo-paired aerial photographs or actually measured with field surveying techniques. Water chemistry options, excluding the previously discussed stream quality survey, include pH and net acidity or alkalinity of all mining-related impoundments. Soil chemistry analysis options such as pH, alkalinity, salinity, toxicity, and nutrients are also available. Chemical analyses can be accomplished by either portable field equipment or laboratories. A mined land inventory can employ any combination of these survey parameters and techniques.

There are also a host of options pertaining to specific sampling or mined land inventory site selection and sampling frequency determinations. Four optional approaches are presented below:

1. Spot sample all major disturbed minesites identified by aerial mapping.
2. Categorize minesites by method of mining, area geology and spot sample each category.
3. Spot sample only those minesites which are producing adverse stream effects.
4. No field sampling, obtain all data from aerial map interpretation.

Field work can be minimized and data acquisition maximized by using one of a number of aerial photo-mapping techniques. Preliminary survey work which can be completed using these photo maps includes determination of surface mine boundaries, exposed highwalls, pit areas, ponds, waste or refuse storage areas, degree of regrading, and degree of vegetative cover.

Aerial Photography

Careful analysis of mapped data from previous studies may be instrumental in definition and delineation of working watershed or subwatershed units (modules) and in determination of aerial mapping requirements. If problem areas or areas warranting further study cannot be accurately delineated using existing mining and water quality data, it may (as is often the case) be necessary to acquire more detailed information, particularly in the form of photographic coverage from such sources as high level aircraft or Earth Resource Technology Satellite (ERTS). Depending upon the level of detail required and availability of existing aerial photography or mapping, the agency establishing a statewide abatement program may elect to initiate its own detailed aerial survey after the major mining areas of the state have been identified. If new aerial photography of the study area is to be obtained, a number of photographic technical alternatives must first be considered and a decision made to provide maximum photo usability at minimum project cost and effort.

There are a number of optional types of image format (film type) that should be considered when planning acquisition of aerial photography. The choice depends largely on degree of detailed information to be interpreted from the photographs: topographic and geological features; stream conditions; soil conditions; or vegetation cover and identification. For instance, the following represent a few of the many options available to the administering agency:

Film Options

Film Type	Use
1. Black and White Stereo	Identify topographic features
2. Color Stereo	Identify topographic and geological features, water turbidity, and soil conditions
3. Infra-red False Color Stereo	Identify topographic and geological features, water turbidity, soil condition, percent cover and vegetation identification

For most state's land inventory programs, Black and White Stereo photography will supply the necessary information with maximum return on investment costs. However, in some parts of the country where the number of cloudless days per month is low, Infrared False Color Stereo may prove to be less expensive and reduce lag time between planning and field survey work. Table 4-2 illustrates the number of cloudless days per month for various parts of the country. To understand how this affects project costs, a short explanation of the cost elements of photographic services will help.

Table 4-2

NUMBER OF CLOUDLESS (10% or Less Cover) DAYS PER MONTH FOR SELECTED STATES

STATE	LOCATION	YEARS OF RECORD	MONTH												TOTAL PER YEAR	AVE. PER MONTH
			Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.		
Massachusetts	Nantucket	37	1.1	1.4	2.5	2.0	1.9	0.7	1.1	1.7	1.8	2.8	1.5	1.0	19.4	1.6
Pennsylvania	Harrisburg	37	4.1	4.1	5.0	4.5	4.6	2.9	3.7	4.2	6.6	7.5	4.2	3.5	54.8	4.6
Missouri	Springfield	37	9.1	8.3	8.2	8.7	9.3	10.2	12.4	11.8	11.4	13.1	10.6	8.6	121.7	10.1
Arizona	Phoenix	37	12.5	10.4	12.1	14.8	18.2	20.7	10.7	10.5	16.9	18.9	15.7	13.7	174.9	14.6
	Yuma	37	18.1	15.9	19.2	21.7	25.8	26.6	20.9	21.0	23.4	24.0	20.9	18.8	256.2	21.4
California	Eureka	37	3.7	3.2	4.1	4.4	4.2	4.6	3.2	3.4	5.9	6.1	4.2	4.2	51.4	4.3
	Fresno	37	5.6	6.7	9.6	12.9	10.3	21.6	25.2	25.6	22.4	19.5	12.8	6.7	184.9	15.4

Adapted from Reference No. 67

The total cost for an aerial survey is affected by the following factors:

1. Size of the area to be photographed
2. Final scale of the maps
3. Film type and processing
4. Actual flying time
5. Flight personnel stand-by time (weather conditions - cloudless days)
6. Quality and quantity of map interpretation
7. Quantity of ground truth data
8. Unproductive lag time between aerial map planning and beginning of watershed sampling program

As can be seen readily, film and processing costs are only a small part of the total price. The ultimate intended use of the aerial photos will determine the need for aerial photography, the scale (detail resolution) and type of film best suited to survey needs. Following is a summary of potentially suitable photo scales, their resolutions, the scale at which original photography must be acquired (to permit development of desired final photo scale), possible uses, and approximate costs per 250 square kilometers (100 square miles) coverage for photography and photomapping.

1. Final photo scale: 1 cm. = 240 m. (1 in. = 2000 ft.)

   Aerial photography at this scale would be well suited to most major statewide inventories covering areas of over about 250 square kilometers (100 square miles). For smaller study areas, an expanded map scale might be better suited. Original aerial photography scale for developing this final map scale is 1:80,000. Costs for this photography are approximately $100 per 250 square kilometers for black and white photography, $130 per 250 square kilometers for color or infra-red. Color or infra-red enlargements are not extremely useful because resolution is poor and much detail is lost. Black and white enlargements are best suited for use in these studies, and can be developed from either black and white, color, or infrared original photography.

2. Final photo scale: 1 cm. = 120 m. (1 in. = 1000 ft.)
   This scale of photography is well suited to intermediate sized study areas, generally those less than 250 square kilometers, or those with widely scattered mined areas. In the latter case, complete photo coverage of the state or study area would not be required, and 1 cm. = 120 m. photo could be produced only for the mined areas. Original aerial photography for this final scale must be flown at 1:40,000 scale, and costs $300 per 250 square kilometers for black and white photography or $400 per 250 square kilometers for color or infra-red photography. Rectified enlargements to black and white photos at the desired final photo scale costs an additional $300 per 250 square kilometers.

3. Final photo scale: 1 cm. = 48 m. (1 in. = 400 ft.)
   This photo scale is best suited for very small study areas such as individual sub-watershed areas or minesites. It could also be used as spot photography in statewide studies where mined areas are very small and widely scattered. The original photography required to develop this final scale must be flown at 1:16,000 scale, and costs $800 per 250 square kilometers for black and white and $1,050 per 250 square kilometers for color or infra-red. Rectified black and white enlargements to the desired final photo scale would then cost an additional $1,700 per 250 square kilometers from black and white, color, or infra-red originals.

In many cases, particularly where study areas are relatively large, the detail resolution of the 1 cm. = 240 m. (1 in. = 2000 ft.) scale may be optimal for mined land inventory surveys. A primary benefit of this photo scale is its coincidence with the scale of the USGS 7.5 minute topographic quadrangles, which are available for nearly all portions of the Nation. Use of identical photo and topographic map scales also minimizes problems encountered in transferring data from one to another.

Photography at this scale can be obtained in several ways.

Low altitude aerial photographs, including those used for mine or construction site photogrammetric mapping (1 cm. = 24 m.) can be pieced together to form a composite of the study area and photographically reduced to the desired scale. However, photographic distortion and variations of photo quality could yield a 1 cm. = 240 m. (1 in. = 2000 ft.) scale photo of unacceptable quality. The best quality for photography at this scale is obtained at high altitude, where the center of an aerial photograph can be planned to correspond to the center of one of the USGS topographic quadrangles in the study area. In this manner, the entire 7.5 minute "photomap" is contained on a single aerial photograph with no breaks and no variations in quality, and quality is much improved when the photos are enlarged to the desired scale. A disadvantage of this high altitude aerial photography is that perfectly clear, non-hazy days are required to permit acceptable photographs to be obtained at the required altitude (as high as 7300 m. or 24,000 feet). Thus, it may take some time for a sufficient number of such clear days to occur, particularly in the east where air pollution, hazy skies and temperature inversions are common.

Depending upon the extent and condition of the mined areas in the study, other photo scales may be more desirable from both a management and an economic standpoint. For example, states with relatively small tracts of disturbed land in isolated areas may wish to limit photographic coverage to those isolated areas and utilize an expanded photo scale which can also serve as final reclamation planning photography. Where individual mined areas are extremely large in overall size or are uniformly but widely scattered throughout the study area, a smaller scale such as 1 cm. = 360 m. (1 in. = 3000 ft.) or 1 cm. = 480 m. (1 in. = 4000 ft.) may be able to provide adequate detail at a lower overall cost. These options relating to photo scale must be considered prior to initiation of aerial photography.

Photo Interpretation

The method of completion of photo interpretive work on 1:24,000 scale photographs will depend to a large extent on size of study area and number of parameters and level of detail required for mined land assessments. Where the study area is large, preliminary photo interpretive work can be accomplished in two manners:

1. Stereometrically interpreting the stereo-paired photographs, or
2. Using fixed wing aircraft or helicopters.

Use of aircraft or helicopters is best suited for this work because it is faster, easier, and more accurate at this scale than stereometric work at a comparable cost. The increased speed of such an approach may help to regain any time lost because aerial photography was delayed by inclement weather or hazy skies.

To simplify accomplishment of this task, and to insure consistency in all interpretive work done, parameters for definition and classification of surface mined lands should be established early and distributed to personnel doing actual field classification work. A careful consideration of the many important surface mine characteristics or combinations of characteristics is required to devise a satisfactory system to categorize these lands. A complex classification system may be too confusing to the field crews, particularly when aerial reconnaissance is to be employed. A complex system may also be impossible to simply and clearly show on the 7.5 minute photomaps, particularly in extensively mined areas. A fairly simple mined land categorization can be established based on the amount or extent of reclamation effort required to return the land to a useful condition. The phrase "reclamation effort required" refers to degree of difficulty of an anticipated reclamation project, which is directly related to the present physical condition of a surface mine site, and will ultimately be reflected in the cost of reclaiming that site. A typical surface mine classification system might involve five categories of mined land:

1. Active surface mines;
2. Surface mines that are generally completely reclaimed, requiring only local spot reclamation work;
3. Surface mines in which only a minimal reclamation effort is required;
4. Surface mined land requiring a moderate reclamation effort; and
5. Surface mined land requiring extensive reclamation work.

Although such a surface mine classification is relatively simple to describe and explain, much personal judgment is required to place each surface mine observed into one of the listed categories, particularly one of the latter three categories. Different interpretations of each category by various personnel involved in field interpretation work could easily result in an inconsistent classification system.

To simplify the classification task for field personnel, a broad and easily defineable classification system can be developed based on the most critical characteristics of the unreclaimed surface mined land. The number of characteristics utilized will, of course, vary with individual studies or extractive industries. A typical three-characteristic classification system might consist of the following:

1. The extent of regrading completed after mining;
2. The degree of revegetation of the spoil material;
3. The angle of slope of the surface mined area, referring to the general configuration of the land prior to initiation of mining.

The extent of regrading might be broken down into ungraded, completely regraded, and partially regraded. Partially regraded here could refer to areas in which regrading was only completed in portions of a mine or where only minimal regrading, such as spoil bank rounding or any other poor reclamation work in compliance with older, ineffective reclamation laws was initiated. Areas which have been satisfactorily regraded utilizing any of the conventional techniques could be classified as completely regraded. The angle of slope can be judged from undisturbed land surface adjacent to each mined area.

Field personnel doing photo interpretation and strip mine classification work can choose any of the categories rating each of these critical characteristics - extent of regrading, amount of revegetation, and degree of slope. Each of the potential characteristic ratings could be assigned a letter designation. Thus the description of the condition of each strip mined area would involve a three letter rating - one letter each for the critical site characteristics - slope, grading, and vegetation conditions. This detailed classification can then be cross-keyed to the five broad reclamation categories to be used in final mapping and reclamation cost projections. An example of an entire surface mine classification system as would be used by the field personnel is shown in Table 4-3.

Depending on the mineral industry being evaluated, underground mining may also be included in watershed survey mapping or mined land classification system. However, any underground mining information presented must primarily be developed from field surveillance, or other sources, because most abandoned underground mine openings are not readily discernable on aerial photomaps or during aerial or stereometric surveillance. Sources of data delineating deep mine openings are:

1. Existing specific mine drainage studies.
2. States' Departments of Environmental or Natural Resources' mining records, geologic mapping, and index maps showing underground mine openings.
3. The U.S.B.M. Mine Map Repository has an extensive collection of mine maps (including maps collected by the States' Geological Surveys).

These mine openings and boundaries, once located, can be plotted on the photomap overlays with the surface mines.

Mine opening locations should be adjusted, if possible, from aerial reconnaissance and visual review of the photos. Underground mine openings that are known pollution sources can also be designated with an appropriate symbol, and may be further categorized by relative size of pollution load, where sufficient information is available to make these distinctions. Each underground mine opening can be given a number unique to that particular USGS quadrangle sheet, and a list of mine numbers can then be compiled for each sheet. Names of the mineral seams or veins mined could, where applicable, be listed for each mine opening. Here again, the level of detail needed for this specific information may exceed that attainable within the individual study framework, and the information may not be available until subsequent, more detailed, implementation stages begin.

These surface mine classifications (both the three letter designations and the final numerical classification), and the underground mining information can be shown on a set of working photographs used in the field. The photo-interpretive work also involves several other steps, once individual surface mine conditions are

Table 4-3

TYPICAL SURFACE MINE CLASSIFICATION SYSTEM

Mapped Classification of Surface Mined Land

1. Active
2. Completely Reclaimed
3. Minimal Reclamation Effort Required
4. Moderate Reclamation Effort Required
5. Extensive Reclamation Effort Required

Field Classification of Surface Mined Land

A. Ungraded
B. Partially Regraded
C. Completely Regraded

D. Unvegetated (less than 40% cover)
E. Partially Revegetated (40-80% cover)
F. Completely Revegetated (greater than 80% cover)

G. Level Slope (less than 10°)
H. Moderate Slope (10-20°)
I. Steep Slope (greater than 20°)

Classification Cross Index

Field	Mapped	Field	Mapped	Field	Mapping
ADG	4	BDG	3	CDG	3
ADH	5	BDH	4	CDH	3
ADI	5	BDI	5	CDI	3
AEG	4	BEG	3	CEG	3
AEH	5	BEH	4	CEH	3
AEI	5	BEI	4	CEI	3
AFG	3	BFG	3	CFG	2
AFH	3	BFH	3	CFH	2
AFI	4	BFI	3	CFI	2

examined, ascertained and categorized by field personnel. All surface and underground mines and the small bands of adjacent land disturbed by their operations should be outlined and classified. Highwalls can be defined, and mine impoundments can be delineated on the photographs, as well as slurry ponds, refuse piles, underground mine openings and other features on the photos where distinguishable.

Quarries, gravel pits, other types of extractive operations, and logging operations, which on the photos may resemble operations of the industry under scrutiny, can also, in many instances, be roughly shown to insure that field crews have checked for stripping in those areas. All pertinent information can then be transferred from these field photographs to overlays being developed for the 7.5 minute photomaps. These map overlays are discussed in more detail in the "Final Mapping" portion of this chapter.

Terrestrial Survey

To provide full assurance that field crews' aerial photo-interpretations of mined lands are as accurate as possible within the framework of the project's goals, field auditing of the photo-signature data can be conducted.

This audit can be performed in conjunction with the terrestrial survey of the study area designed to ascertain study area mine-site conditions. The level of effort of this terrestrial survey and photomap audit will vary according to detail required, specific study goals, size of study area, and time and funds available. A representative sampling effort can be formulated to insure maximum area coverage and accuracy at a minimum expenditure of time and money. In watersheds with extensive and varied mining conditions, field surveillance should be increased to insure accuracy in sampling. The field audit of photomapping generally involves in-depth reconnaissance of selected representative surface mined areas to verify field interpretations of reclamation characteristics, accuracy of plotted surface mine outlines, ponds and highwalls. Where mined land classifications are derived stereometrically, intent of the auditing program should be to conduct audit work as directed or requested to aid and confirm stereoscopic photo-signature work in areas where difficulties are encountered. In summary, terrestrial surveys are performed for the following reasons:

- Establishing ground truth of photo-interpretation;
- Verification of existing historical data;
- Supplementing existing information through collection and analysis of additional field samples; and
- Increasing the investigator's familiarity with overall field conditions.

An essential aspect of field surveillance activities is preparation and training of field crews. Since terrestrial surveys are important to the overall accuracy of the study, it is imperative that field personnel record, collect, and manipulate field information in a usable and consistent format. Preparation of field crews should include:

1. Orientation to survey goals and objectives;
2. Assignment of team duties and watersheds;
3. Instruction on use of sampling and testing equipment and completion of data sheets.

This orientation and training process should be conducted under field conditions and a procedural document should be developed for field personnel use throughout the survey.

Recording of visual observations, as well as results of field tests, should be entered upon standarized data sheets specifically designed for the terrestrial survey. Depending upon the particular parameters selected for monitoring, the data sheets should contain information regarding:

- Name of field investigator;
- Recording data;
- Location of site - tier and range designation, watershed number, township, county, state;
- Estimated acreage of site;
- Site access;
- Biological, physical, and chemical conditions;
- Wildlife use;
- Special remarks by field recorder;
- Results of laboratory tests of field samples;
- Computations subsequently performed by field personnel.

For best results, 7.5' topographic maps and/or photos at 7.5' topographic scale should be utilized with data sheets in recording field observations. If results of field investigations are to be manipulated by computers, data sheets must be encoded in a manner compatible with the software to be used. In such instances a computer programmer is a valuable assistant in design of field data sheets.

In addition to determination of the watershed's terrestrial quality, it should be evaluated in terms of existing reclamation status and potential site improvement. This may be accomplished simultaneously with collection of terrestrial quality data.

Reclamation potential of an abandoned mine site is directly related to the extent of environmental impact caused by extraction methods utilized during the mining cycle. Details of the relationship between mining, environmental impact, and reclamation potential were described earlier in this report.

Evaluation of watershed and mined land reclamation potentials should include data concerning the following:

- Mining methods
- Mineral commodity extracted
- Age of disturbance
- Acreage of mined site
- Site conditions
- Major environmental areas
    a. Erosion and sedimentation
    b. Refuse or waste materials
    c. Water
    d. Toxic materials
- Adjacent land uses

Although optional at the statewide inventory level, evaluation of availability of reclamation resources, assessment of general reclamation techniques, and an estimate of the degree of difficulty in reclaiming the area, will be valuable and save time and resurvey cost during implementation of the overall pollution abatement and abandoned mined lands reclamation program.

Although mined lands surveys such as the two just presented attempt to represent the major types of environmental conditions, the data does have certain use restrictions.

1. The data collected can only represent the actual sites investigated. Extrapolation of this data for conditions of the entire inventory area is through inference only and is subject to variance.

2. The data depicts only conditions that exist at the moment the site was examined and do not reflect seasonal changes or trends.

3. The data cannot be used to depict any one commodity or condition for an entire watershed or state. It only serves as an illustration of the conditions as they exist in a watershed or a state.

The survey data does, however, provide a foundation for summarizing characteristics and conditions of mining environment for evaluation and ranking purposes. This data also serves as a basis for determining major costing factors and definition of magnitude of remedial measures which will comprise the restoration, reclamation and rehabilitation activities of the program.

Land Ownership

A major problem in abandoned mined land reclamation affecting priority establishment is the land ownership question. Public ownership of unreclaimed mined lands simplifies reclamation work in several ways. Access costs and problems are eliminated, and the question of benefitting private landowners with public funds does not arise. Land use and recreation benefits are generally higher for reclamation on public land versus private. Reclamation results in upgrading of present public holdings, but reclamation on private lands also benefits nearby public holdings by upgrading area aesthetics and enhancing wildlife populations.

Ranking of watersheds into categories according to the percentage of abandoned mined land that is publicly owned represents only one means of handling this question. Categorization could use the following system:

1. High - greater than 67% public ownership
2. Medium - between 67% and 33% public ownership
3. Low - less than 33% public ownership
4. None

In addition, categorization could include division of privately owned land into classes corresponding to potential for reclamation. However, this may be beyond the scope or level of detail of many larger statewide abatement studies. A typical breakdown for privately owned land is shown below.

1. Mining Companies - ownership of surface and mineral rights.
2. Corporation - ownership of surface rights.
3. Private Individual - ownership of surface rights but mineral rights belonging to mining company.
4. Private individual - ownership of both surface and mineral rights.

The information needed to document land ownership can be obtained from U. S. Geological Survey Topographic Maps, County Maps, local tax records, and other available sources. If time and budget expenditures permit, courthouse recorded deeds can be utilized; however, this process is extremely difficult and time consuming at this phase of planning a statewide abatement and reclamation program.

RECLAMATION COST DEVELOPMENT

The principal environmental damages resulting from mining of any mineral are disruption of the land surface and/or production of mine drainage pollutants which subsequently degrade surface and ground water. Statewide abatement planning studies should, therefore, include mine drainage abatement as an integral part of the comprehensive long range mine reclamation program that is developed.

The high cost of surface mine reclamation is seldom justified from a future land use standpoint, because land value increases following reclamation are relatively small compared to the actual reclamation costs, due to the remote locations of many sites. An economic justification for expenditure of public funding to cover the reclamation cost - land value improvement cost differential in surface mine reclamation can often be derived only from water quality improvement benefits. Abatement of mine drainage from abandoned underground mines has no future land use benefits. Therefore, total justification must primarily be derived from water quality improvements and the resultant socio-economic benefits within and downstream from each pollution source. Benefits derived from future land use potentials should generally be only a secondary consideration.

Significant water quality improvements may not accrue from surface mine reclamation alone in areas of extensive surface and underground mining. Estimates based on numerous watershed studies in the Appalachian coal fields have placed underground mine contributions of acid mine drainage at 75% of the total amount of pollutants produced in the bituminous coal fields. Underground and surface mine drainages are often interrelated, and it may be difficult to distinguish which source is causing pollution without an intensive study. However, some effort should be made to distinguish between the loadings of mine drainage emanating from surface mines and underground mines in all pollution producing watersheds within the study area. This will permit the relative water quality improvements resulting from surface mine reclamation and underground mine pollution abatement to be evaluated, compared, and totalled for each polluted watershed.

Surface Mine Costs

Computation of surface mine reclamation costs for each of the study area watersheds should begin as the surface mine classification and signature work is completed. This phase of the study can proceed in several steps, including development of average reclamation costs, computation of areas, and calculation of costs.

Development of average reclamation costs for each category of unreclaimed mined land can be completed as soon as the categories are developed. These average costs should be based on all available mined land reclamation figures or estimates. Depending upon the specific mining industry in question, such reclamation estimates or cost records may already be compiled in some form or another. For example, reclamation and mine drainage abatement costs for the Appalachian coal mining industry have been assessed and compiled in a report entitled "Analysis of Pollution Control Costs" by Michael Baker, Jr., Inc. for the Appalachian Regional Commission. This study, published in 1973, examined data for all reclamation projects completed to date, and established average reclamation costs from this data. Similar sources of data may exist for many other mineral extractive industries, and can provide valuable insight during establishment of realistic reclamation and pollution abatement costs. Where such data has not been compiled, recognized experts can be consulted to determine the best mode of reclamation or pollution abatement and to establish costs of such measures. In addition, it will frequently be possible to transfer technology and cost estimates from one extractive industry to another, where conditions and requirements are reasonably similar. In any event, costs incurred in reclamation and abatement efforts in other similar industries should at least be considered prior to establishment of costs.

Once sufficiently detailed cost data has been obtained, it is necessary to establish individual costs for the various mined land categories defined earlier in the study. As the level of effort required to return land to full utility increases, reclamation costs will increase. This must be taken into account as reclamation costs, preferably on a per hectare or per acre basis, are established for each class of surface mine or surface feature.

The following surface mine reclamation costs, broken into six distinct classes, represent a typical or possible division of land categories and reclamation costs. In this case, the mined land classification relates to the coal fields of west-central Appalachia. Brief descriptions of reclamation categories, costs applied, and justification for applying these costs follow:

Class 1 - This class consists exclusively of active strip mines, regardless of whether coal extraction or reclamation is in progress. Existing state surface mining rules here require complete reclamation of all active surface mined lands by the operator and are stringently enforced. Therefore, no reclamation costs are applied to Class 1 strip mines.

Class 2 - Class 2 strip mines have generally been satisfactorily reclaimed, minimizing need for application of additional reclamation costs. A reclamation cost of $250 per acre is applied to lands in this class to permit limited spot treatment or reclamation where required.

Class 3 - These strip mines generally exhibit some degree of reclamation, whether by partial regrading and revegetation or by natural recovery of vegetative species on unreclaimed mine surfaces. An average reclamation cost of $700 per acre is applied to all Class 3 lands. This value includes $400 per acre for soil preparation and revegetation (an average cost reported in the "Analysis of Pollution Control Costs") and an additional $300 per acre for any additional minor regrading or recontouring required.

Class 4 - Class 4 strip mines are those requiring a moderate reclamation effort, and are expected to represent the average condition of the coal field's unreclaimed strip mined lands. Information presented in "Analysis of Pollution Control Costs" was the basis for the reclamation cost derived for this class. The report cited an average reclamation cost of $1,650 per acre, which included backfilling, regrading, soil preparation and revegetation. This average value based largely on reclamation work done in Pennsylvania, West Virginia and Maryland, is lowered somewhat to account for the generally less rugged terrain of the study area's strip mined lands. An average reclamation cost of $1,500 per acre is applied to all Class 4 strip mined lands.

Class 5 - This class represents strip mined land in which an extensive reclamation effort is required. Such strip mines are generally unregraded, unvegetated and located on steep slopes. The steep slopes, in particular, greatly increase reclamation costs for Class 5 strip mines. Based on previous reclamation experience, a cost of $2,500 per acre is applied to all Class 5 strip mined land.

Class 6 - Surface mine reclamation techniques are also applied to refuse piles, which consist of waste materials from underground coal mines. This deep mine refuse material is generally much more toxic than strip mine spoil and as a result, reclamation is more difficult and costs are higher. A reclamation cost of $3,000 per acre is applied to all refuse piles.

Every completed photomap used in a statewide abatement study delineates the boundaries of the area affected by each surface mine, and places those mines or refuse areas into a category similar to those discussed above. As the mined land classification work on these photomaps is completed, the areas of all surface mines and refuse areas on each map can be accurately computed using planimeters. The acreages for each reclamation category within each of the study area modules or watershed units can then be totalled and tabulated. Average reclamation costs such as those presented above can be applied to each category in each watershed. This permits the total surface mine reclamation cost to be calculated for each watershed.

Underground Mine Costs

The task of establishing underground mine pollution loads and computing abatement costs can be extremely difficult, particularly where the study area is large and where study time and available information is limited. These problems do not affect surface mine cost computations since those are based on accurate areas computed for each category of surface mined land and on fairly straight-forward cost per acre figures. Underground mine pollution load estimates and abatement costs must be developed in an entirely different manner, and may represent one of the most complicated and difficult challenges of an entire statewide abatement program. The methods with which underground mine abatement costs can be estimated are highly variable, depending almost exclusively upon the amounts of deep mining and mineral geology information available. This, in turn, is at least partially related to size of the study area and time allotted for the study. It may not be possible to compile extremely detailed information for a massive study area, particularly when project time is limited. The manner by which underground mine pollution abatement costs are estimated will, therefore, vary radically in different situations, and the final methodology for estimation will have to be established by project personnel in each individual study after assessment of available data.

Regardless of the option selected or devised for determination of deep mine pollution abatement costs, a system must still be devised to estimate the portion of each module or watershed's pollution load that emanated from underground mines. In most situations, at least a portion of the abatement costs will have to be based upon the pounds of underground mine pollution to be abated. Derivation of underground mine pollution abatement costs could proceed in a series of steps similar to those discussed below, according to the volume and detail of available background data. It must be pointed out that the methods discussed may vary with specific minerals, mining techniques, and available time.

Extensive Background Information

Existence of extensive background information and availability of time to accurately compile and utilize that data can eliminate much guesswork and inference from the process of underground mine pollution abatement cost development. The first step in this cost development is determination of the percentage of pollution of underground mine origin in a given watershed. Water quality data will usually not provide the detailed point source information necessary to determine this, since the water sampling programs are fairly general in nature and strive to pinpoint pollution source areas rather than specific sources. The method best suited for estimating underground mine pollution contributions involves a two step approach:

1. Establish the relative amount of surface and deep mining in a given module or watershed;
2. Determine percentage of total pollution load that emanates from deep mines once the intensity of deep versus surface mining has been established.

The relative amounts of surface mining versus deep mining in a watershed or module are first established. The percentage of each watershed's total area that consisted of surface mines requiring substantial reclamation must first be determined. Based on these computed percentages, polluted watersheds are placed into one of four categories of surface mining intensity - heavy, moderate, light or no surface mining.

The second step in computing underground mine pollution abatement costs is assessment of the extent of underground mining in each polluting watershed, utilizing categories similar to those applied to surface mining. The most accurate method of determining this is to plot and compute the areas of all underground mines (or all underground mines in known pollution forming seams or veins, if pollution capacity varies to any noticeable extent) from the actual underground mine mapping. Individual mine maps may be available from the appropriate state department - one dealing with natural resources, environmental protection, mining, or geological survey. These same agencies may, in some cases, have compiled summary or composite maps, possibly delineated by mineral seam or by geographic area, showing many or all of the underground mines.

Using available mine mapping information, the extent of underground mining in each of the pollution - producing watersheds can be classified in much the same manner as was surface mining - heavy, moderate, light, none. Placement of each watershed into one of these categories can be based on actual areas of underground mining, either all mining or mining exclusively on known pollution producing seams.

Conversion of these underground mine and surface mine ratings to percentages representing mine drainage pollution loadings of underground and surface mine origin in each polluting watershed can subsequently be accomplished by developing a simple chart such as that in Table 4-4. This chart presents various possible combinations of underground and surface mining intensities and the percentage of mine drainage pollutants attributed to each. To develop such a chart, some basis must be established for computing or estimating percentages. The chart presented here represents Appalachian coal mining, where extensive studies have been conducted to assess relative surface and underground mine pollution production. These studies have revealed that in acid-producing coal seams in areas of approximately equal surface and underground mining activity, underground mines account for at least 75% (and frequently as much as 95%) of the mine drainage pollution. Therefore, in watershed areas or modules judged to contain equal areas of surface and underground mining, 75% of the total measured pollution loading was attributed to abandoned underground mines.

Similar investigations and assessments must be made for

Table 4-4
SEGREGATION OF UNDERGROUND AND SURFACE MINE POLLUTION LOADS

Extent of Surface Mining	Extent of Underground Mining
A. Heavy	E. Heavy
B. Moderate	F. Moderate
C. Light	G. Light
D. None	H. None

Watershed Classification Cross Index

Classification	Percent Pollution Load of Surface Mine Origin	Percent Pollution Load of Underground Mine Origin
AE	25	75
AF	50	50
AG	75	25
AH	100	0
BE	25	75
BF	25	75
BG	50	50
BH	100	0
CE	25	75
CF	25	75
CG	25	75
CH	100	0
DE	0	100
DF	0	100
DG	0	100
DA	100	0

every statewide abatement study performed to establish some base set of percentages from which pollution load contributions can be estimated. Percentage establishment on a study by study basis is mandatory because the respective pollution loadings for abandoned surface and underground mines may vary according to mineral, geographic locale, climate, and geologic and hydrologic conditions. In all cases, figures must be either computed or estimated from data gathered to represent the relative surface and underground mine pollution loading percentages in a typical area where the extent of surface and underground mining is approximately equal. Then, for areas where underground mines are more extensive than surface mines, a larger percentage of acid can be attributed to underground mines. Surface mine pollution percentages can be increased where that technique was more extensively employed.

The final step in this process, actual development of underground mine pollution abatement costs, can also be complicated and difficult, depending on the type of information available and the time allotted for analyzing that information. The most accurate cost estimates will be determined where specific mine mapping containing pertinent geologic data is available. In such circumstances, a combined mine sealing and pollutant treatment program cost estimate can be developed, and relatively accurate abatement costs can be estimated for each underground mine or mine complex within a module. The area of a mine or mine complex and the average dip of the strata will yield the hydraulic head. Since mine sealing is usually feasible and dependable only where hydraulic heads will be less than 9 meters, only those mines should be cost estimated for mine sealing. Abatement in mines or complexes in which anticipated heads will exceed the 9 meters limit should be restricted to treatment, which will be discussed later.

In those underground mines or complexes where sealing costs will be computed, a fixed cost per seal should be utilized. Therefore, an idea of the number of entries to be sealed is necessary. Where specific mine mapping is available, the number of openings in each mine or complex will generally be shown. However, this information may not be available on composite mapping which shows only the locations and general shapes of workings. In such instances, the number of openings requiring sealing must be estimated to permit cost computation. The best method of estimating the number of openings involved is to spot check one or more representative areas to obtain a relatively dependable estimate of the number of mine openings per hectare of mine workings or per hundred kilometers of mineral outcrop.

Determination of watershed abatement costs for all workings in which final hydraulic heads will be less than 9 meters can proceed as soon as the number of openings to be sealed has been estimated. The cost per seal will vary according to the thickness of the seam or mineral vein (affecting seal size and volume of materials required) and any special procedures or precautions necessary to insure seal success. For example, mine seals in underground coal mines would average about $15,000 each, taking into account both seal construction and auxiliary grouting adjacent to each seal, which is often mandatory. Similar average seal costs would have to be established for other mining and sealing situations.

Treatment cost computations for that portion of the underground mine drainage not controllable through sealing are relatively straight-forward, requiring only one assumption or determination. Treatment costs are generally based upon the volume of polluted water treated rather than concentrations of pollutants. Since sizes of underground mines and complexes and general nature of the pollutants are known, the controlling factor in estimating treatment costs - volume of water to be handled - must be either computed or estimated. To accomplish this, the flow from each underground mine or mine complex in question must be established, using either known hydrologic and geologic data or the results of field spot checks (mine size versus flow volume).

Once flows are obtained total treatment costs can be easily computed, provided general cost information for such treatment has been obtained. For example, the cost of treating coal mine acid drainage of any concentration ranges between $0.03 and $0.11 per thousand liters ($0.11 to $0.40 per thousand gallons). For coal mine drainage containing only excessive suspended solids, settling facilities cost $0.001 per liter capacity; and settling facilities must have a 24 hour detention time. Thus, the daily discharge volume of the mine in liters times $0.001 per liter will yield the cost of settling facilities. Sludge disposal must also be considered, and in this case accounts for an additional $0.03 per thousand liter ($0.10 per thousand gallon) basin capacity. These treatment costs will vary of course for different extractive industries because the nature of their pollution production problems varies. Treatment costs suitable for use in these other mining industries are currently being developed and presented by the U. S. Environmental Protection Agency. To obtain the treatment costs for the specific industries and pollution problems in question, personnel performing the statewide abatement studies should consult the appropriate EPA "Effluent Limitations Guidelines and Standards of Performance" document for the mining industry with which the study deals. Once these treatment costs are obtained, computation of realistic underground mine pollution abatement costs for various modules or watershed units will simply be a mathematical exercise.

Limited or General Background Information

Estimation of deep mine pollution abatement costs for situations or studies in which background information on underground mining is limited, is similar in many aspects to the procedures just described. The primary difference between these two alternatives arises in actual estimation of pollution abatement costs once other base data or determinations are finalized. Intensity of underground versus surface mining in each watershed must first be established for each module. Without specific mapping from which accurate areas can be computed, all available general mapping and deep mining information must be assessed to enable accurate estimation of relative surface versus underground mining. It may be necessary to simply estimate the extent of mining (heavy, moderate, light, none, etc.) from visual observation of existing data.

Following determination of the percentages or relative intensities of underground and surface mining, a chart similar to that shown and described in Table 4-4 should be developed. Data presented on the chart will permit approximation of the percentage of the module's pollution load emanating from underground mines. Subsequently, pollution loading attributable to underground mines in each module can be computed, and development of costs can proceed.

Underground mine pollution abatement costs can be computed by applying reclamation costs to each kilogram per day of pollutant attributed to underground mines. Depending upon the mineral involved and available abatement technology, a series of cost factors can be established and utilized to compute underground mine abatement costs for a given module. These cost factors should be based upon the anticipated degree of difficulty in abating pollution as determined from previous experiences in similar underground mining situations. A typical costing scheme employing three cost factors in the computation is presented below, based on conditions common to the Central Appalachian coal fields:

1. A low abatement cost of $550 per kg/day ($250 per lb/day) acid can be applied to the first 50% of each watershed's deep mine acid. This represents the portion of an area's acid that can generally be abated with relatively simple, inexpensive techniques.

2. A mid-range abatement cost of $1,100 per kg/day ($500 per lb/day) acid can be applied to the next 25% of each watershed's deep mine acid load. This higher cost results from the greater complexity of the abatement techniques required to eliminate this portion of the acid mine drainage, assuming the first 50% of the watershed's acid has already been abated.

3. A high abatement cost of $3,300 per kg/day ($1,500 per lb/day) acid is applied to the last 25% of each watershed's acid. This portion of the acid is extremely difficult to abate because the required technology does not yet exist or because the existing potential abatement techniques are not financially feasible. This cost is applied to the entire remaining 25% of each watershed's acid on the assumption that existing treatment techniques will be employed where present technology appears inadequate for permanent abatement.

These cost values would then be applied to the derived underground mine acid loads, and the total underground mine abatement costs computed for each acid producing watershed. Of course, the number of levels of difficulty, the percentages of abatement anticipated at each level, and the dollars per kilogram per day of pollutant abated can be varied according to requirements of the study and characteristics of the subject industry's abatement technology. The approach, however, will be basically the same as that described above; if employed consistently in each watershed or module in the study area, the underground mine abatement costs, while only grossly estimated, will be accurate relative to one another.

COST EFFECTIVENESS

The cost effectiveness of a mine reclamation and mine drainage abatement project is the cost in dollars of eliminating each pound of pollutant emanating from the subject site. These values provide an excellent means by which the relative effectiveness of various reclamation or abatement expenditures can be assessed and compared. Cost effectiveness values are generally obtained by dividing the reclamation or abatement cost by the pollution load attributed to that point source. In certain instances where land improvement rather than mine drainage abatement is the primary goal, cost effectiveness may be improved by dividing the total cost by predicted land value increase. These values are computed individually for the surface mine reclamation work, the underground mine pollution abatement work, and the overall reclamation and abatement work in each of the study areas's pollution producing watersheds. The computed cost effectiveness values can then be analyzed along with several other important factors to determine watershed reclamation priority rankings. Where sufficient knowledge of pollution abatement and mine reclamation exists, it is also possible to lump cost effectiveness values for different modules together according to the effectiveness of respective fund utilizations in abating pollutants. For example, cost effectiveness values of less than $880 per kg/day ($400 per lb/day) pollutant abated may be considered good, while values ranging from $880 to $1,750 per kg/day ($400 to $800 per lb/day) abated may be considered acceptable. Tables can then be derived to show for each polluting watershed the cost effectiveness values and the cost and pollution load parameters from which the values were computed for surface mine reclamation, underground mine pollution abatement, and overall reclamation and abatement.

PRIORITIES

Priority establishment in a statewide abatement planning program is one of the last phases of work, and is dependent upon successful acquisition of all available data on the various topics and aspects of the study previously discussed. This phase is best accomplished by establishing a numerical system for computation of relative priority scores. Previous studies of similar nature have clearly shown that the prejudices of personnel establishing priorities are quite frequently reflected in the final outcome of the work, despite all efforts to eliminate bias. For example, sociologists tend to rate development demand or economic need as the most important consideration in each module; biologists tend to over-rate to overemphasize water quality and pollution loadings, surface mine vegetation or wildlife conditions; and water quality experts tend minimizing the importance of aspects outside their fields of expertise. Establishment of a numerical system in which each distinct aspect of the data is assigned a weighted constant or rank according to its relative importance eliminates the possibility of biased rankings. Such a system can be established at any level of detail, thus precision of data acquired in the study need not be ruined by excessive generalization.

One aspect of determining reclamation priorities which is wholly subjective is the political and social climate of the administering agency or state's citizenry. Such subjective influences can be enumerated and quantified within a watershed by considering the presence, strength, and activity of the following groups:

1. Politically influential groups or persons
2. Occupational and professional groups
3. Environmentally oriented groups
4. Influential news media

Few abatement and reclamation programs take this into account; however, these external and internal pressures are a reality and must be evaluated.

A typical example of such a ranking system is presented below. For the purpose of discussion, we will assume that the principal parameters being considered are:

1. Mine drainage pollution;
2. Development demand;
3. Density of unreclaimed surface mines;
4. Economic need;
5. Public visibility;
6. Visual quality;
7. Public land ownership.

Watersheds are grossly ranked individually in each of these seven categories as High, Medium, Low, and None. Initially, each "High" or favorable rating is given a value of three, "Medium" ratings a value of two, "Low" or unfavorable ratings a value of one, and a zero rating where the particular watershed does not exhibit the characteristic or where a value can not be calculated. The watershed characteristics are then assigned coefficients to adjust the relative importance of each characteristic in the final priority determination. This can usually be accomplished by a simple vote among the personnel of various professional disciplines who are involved in the project - having each member rate each of the characteristics in order or on a ten-point scale. In the example cited here, the following coefficients have been used·

Data Characteristic	Coefficient
Mine Drainage Pollution	9
Development Demand	9
Density of Unreclaimed Strip Mines	7
Economic Need	6
Public Visibility	4
Visual Quality	3
Public Land Ownership	1

The watershed priority value for each data characteristic is then determined by multiplying the data characteristic coefficient by the data characteristic rating. For example, if Development Demand (coefficient = 9) had a "High" rating (value = 3), the resultant watershed priority value would be 27.

Values are totaled for each watershed. Watershed scores are then compared and divided into four groups to establish overall priority ranking of watersheds for the land reclamation program. A "High" priority ranking indicates watersheds where immediate reclamation feasibility studies are desirable. "Medium" priority watersheds are those in which reclamation work is desirable, but should be initiated only after considering all of the "High" priority watersheds. "Low" priority watersheds are those where some reclamation work is required, but is not critical and should not be initiated until the higher ranked watersheds have been considered. Watersheds in which there are no unreclaimed strip mined lands are placed in the "None" category. A similar approach could be utilized to establish any number of final priority groupings, or to generate a list of individual priorities rather than a ranking group.

FINAL PHOTO AND MAP PRESENTATION

Upon completion of data analysis and formulation of conclusions, development of mapping for general presentation of findings and conclusions can be finalized. Much of the information shown on these maps will have been plotted on at least a preliminary basis during the course of the study, either on the photomaps, topographic quadrangle maps, or other working preliminary base maps. Scales of the final mapping could be similar to the working base maps discussed in Base Map Development, and will include the photomaps delineating and classifying mined lands. Scales of the sample maps and overlays in this section are 1:250,000. The following discussion describes the general development of both the final summary base mapping and the detailed mined land inventory mapping.

Due to the large variability and volume of data and conclusions generated in a statewide abatement study, it is desirable and advantageous to use color overlays in the final presentation of data. Proper use of color overlays can strongly project important facets of the study and its conclusions, while still presenting additional background and support information in more subtle tones or shades.

There are any number of methods by which the study data and findings could be expressed in color, but the best suited technique involves use of distinctive color overlays to depict the various information. Development of full color base maps proceeds in a series of steps with the development and compositing of distinct color overlays presenting different aspects of the study, the study are[illegible], or the study conclusions. Following is a discussion of the development of a typical set of color overlays and a composite base map.

The first step in final map development is preparation of a location map which shows the entire study area. This map can also delineate in general locations of pertinent mineral deposits, outlines of watershed boundaries, and can serve as an index to the various segments of study mapping or base mapping such as the 1:250,000 scale maps discussed in following paragraphs. A typical location map showing the location of the sample 1:250,000 scale map developed in this study is shown in Figure 4-3.

Preliminary base map development for this color composite system consists of two separate overlays - one black and one blue. The black overlay, as Figure 4-4 illustrates, contains only culture (roads, cities, political boundaries) and topography. This will, in many cases, be the same preliminary base mapping overlay developed for use throughout the study. The first overlay shown in Figure 4-5 contains only important streams, and may also have been developed earlier in the study. The first stage in the development of final mapping is the compositing of these two overlays to form the final map base illustrated in Figure 4-6. The product is simply a typical topographic map showing streams, roads, towns, topography, etc.

The second overlay illustrated in Figure 4-7 represents the next step in the development of overlays for final mapping. This overlay shows the boundaries of major basins and watersheds or modules as originally defined early in the study. The major basins are named and the watershed or module number designations are shown. In addition, the green overlay contains the boundaries and names of the respective USGS 7.5 Minute Topographic Quadrangles that fall within the base map area. This enables readers to go rapidly and easily from the summary base map to the specific quadrangle map or corresponding photomap if more detailed information is desired.

Addition of this overlay illustrated in Figure 4-7 to the original base map developed in Figure 4-6 yields the second stage composite map shown in Figure 4-8. This stage of the composite map is the first that shows any of the information developed in the statewide abatement study. The composite can actually be considered the true base map for the study itself, since the contents of the included

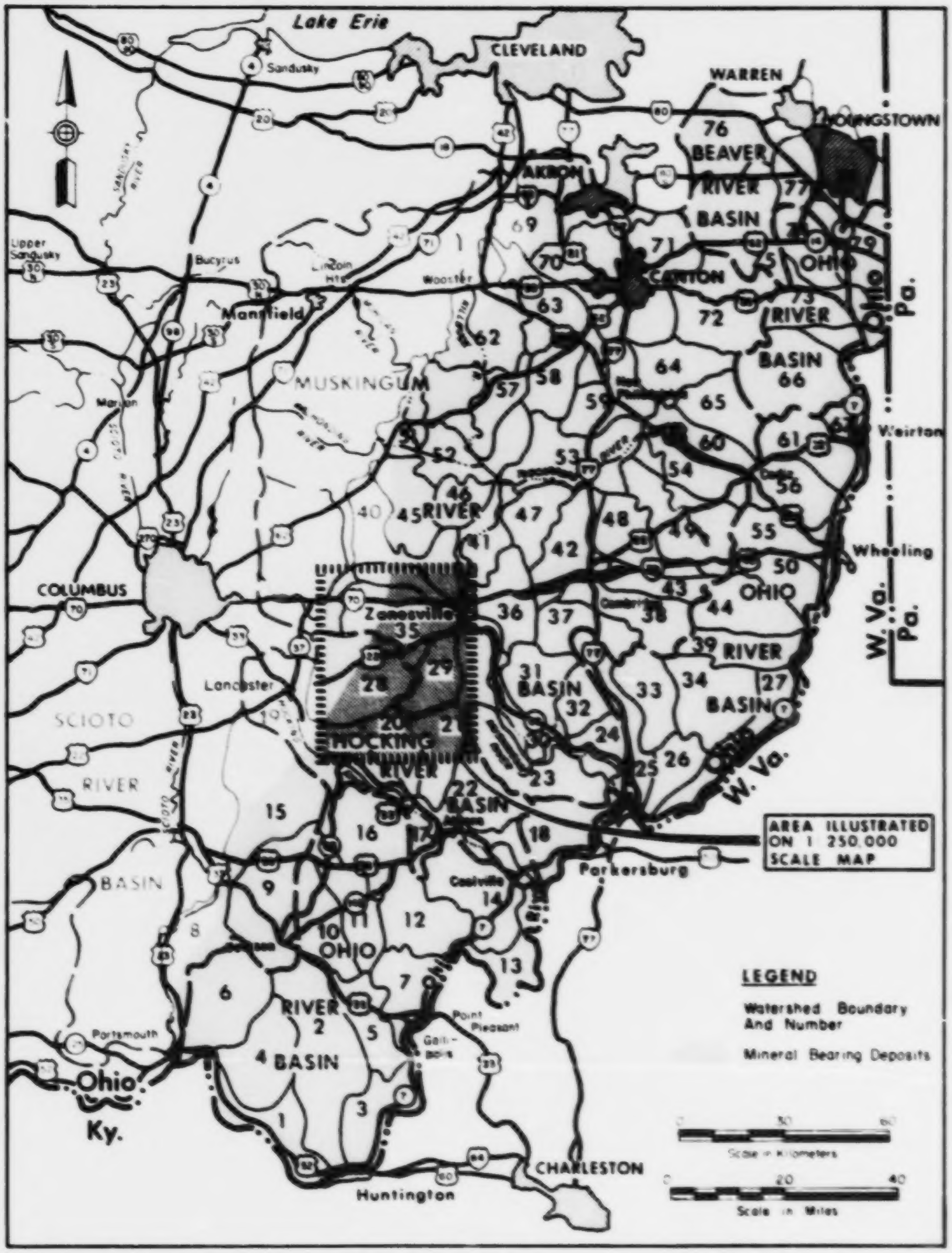

Figure 4-3. Illustration of major river basins and watershed boundaries within area underlain by mineral bearing deposits.

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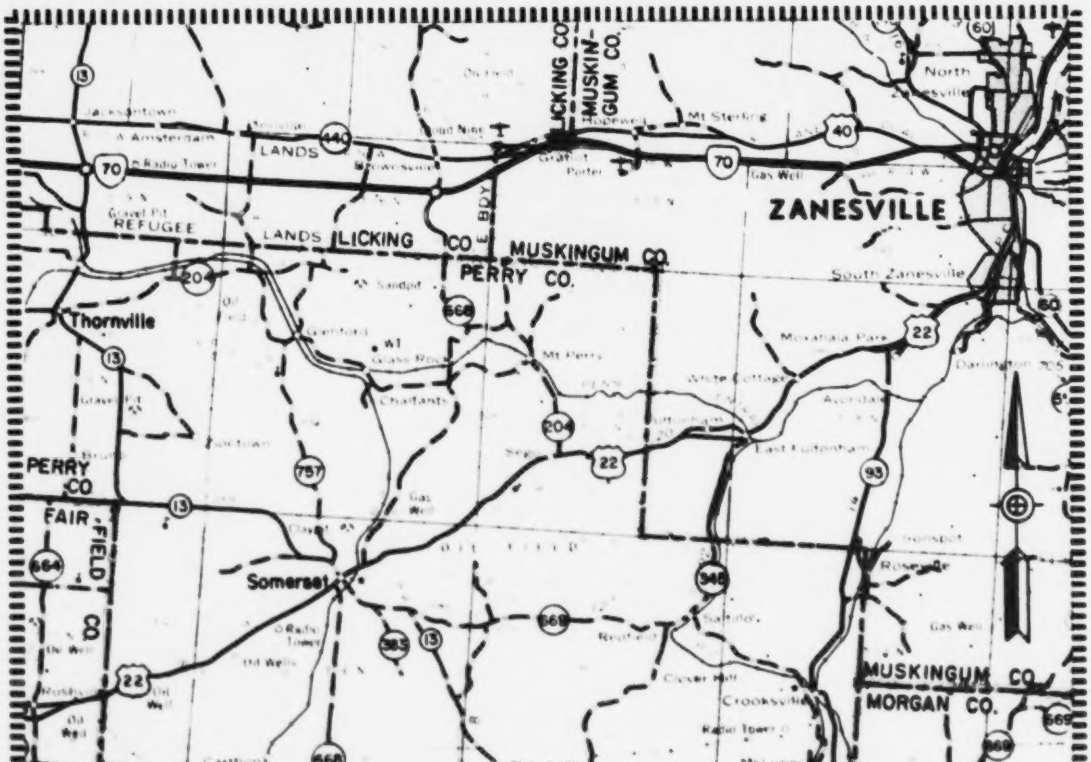

Figure 4-4. Illustration of base map.

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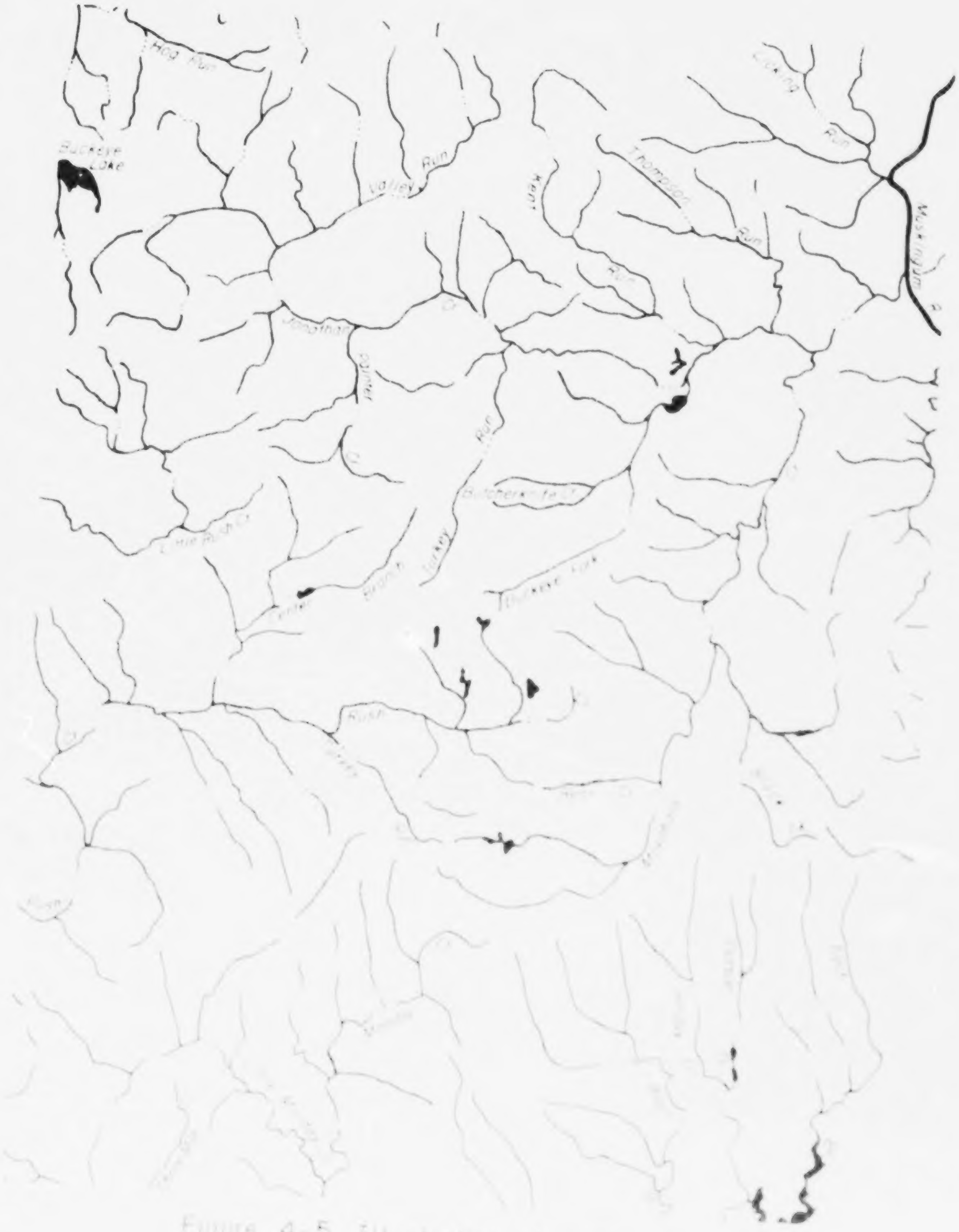

Figure 4-5 Illustration of major streams

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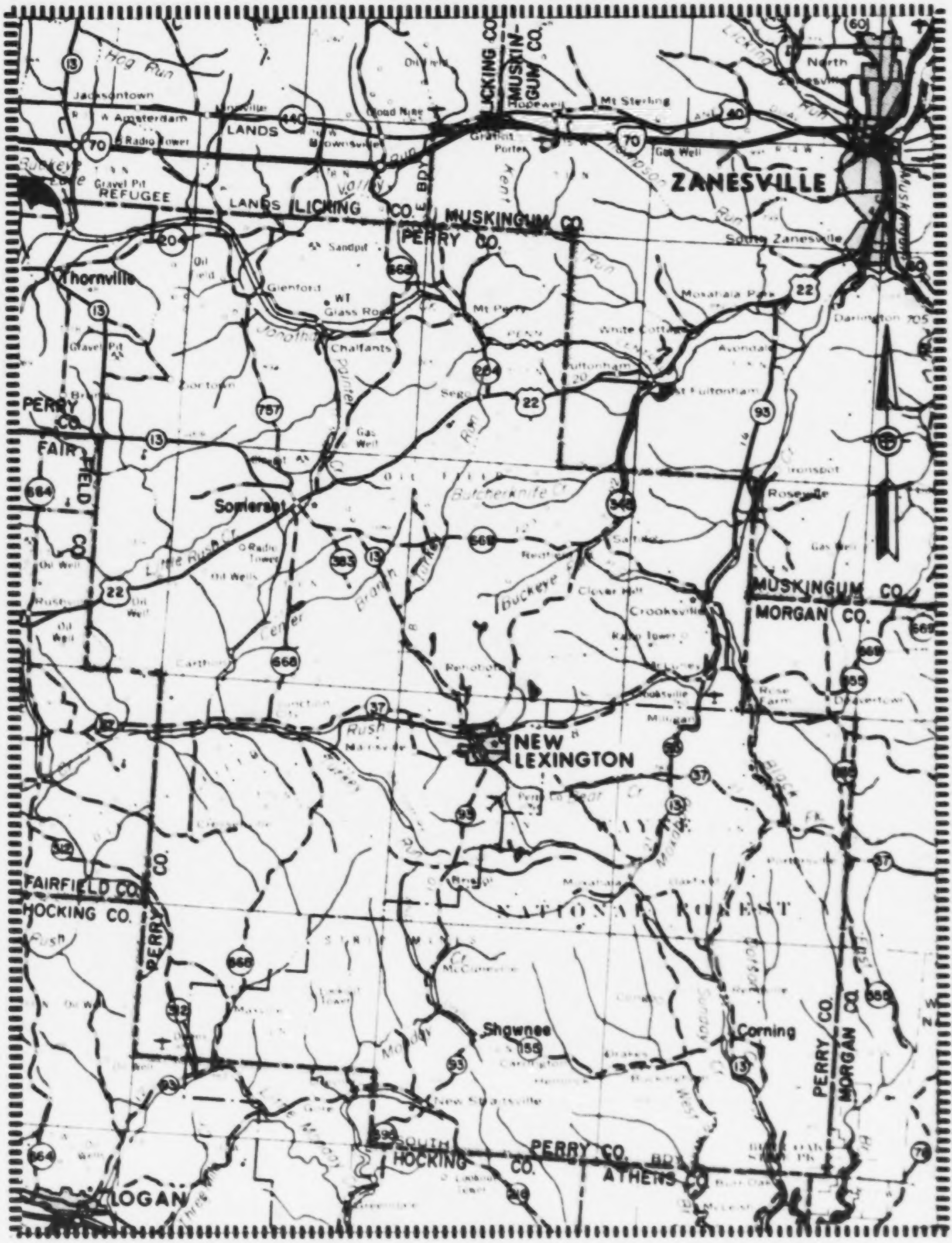

Figure 4-6. Illustration of figures 4-4 and 4-5 superimposed

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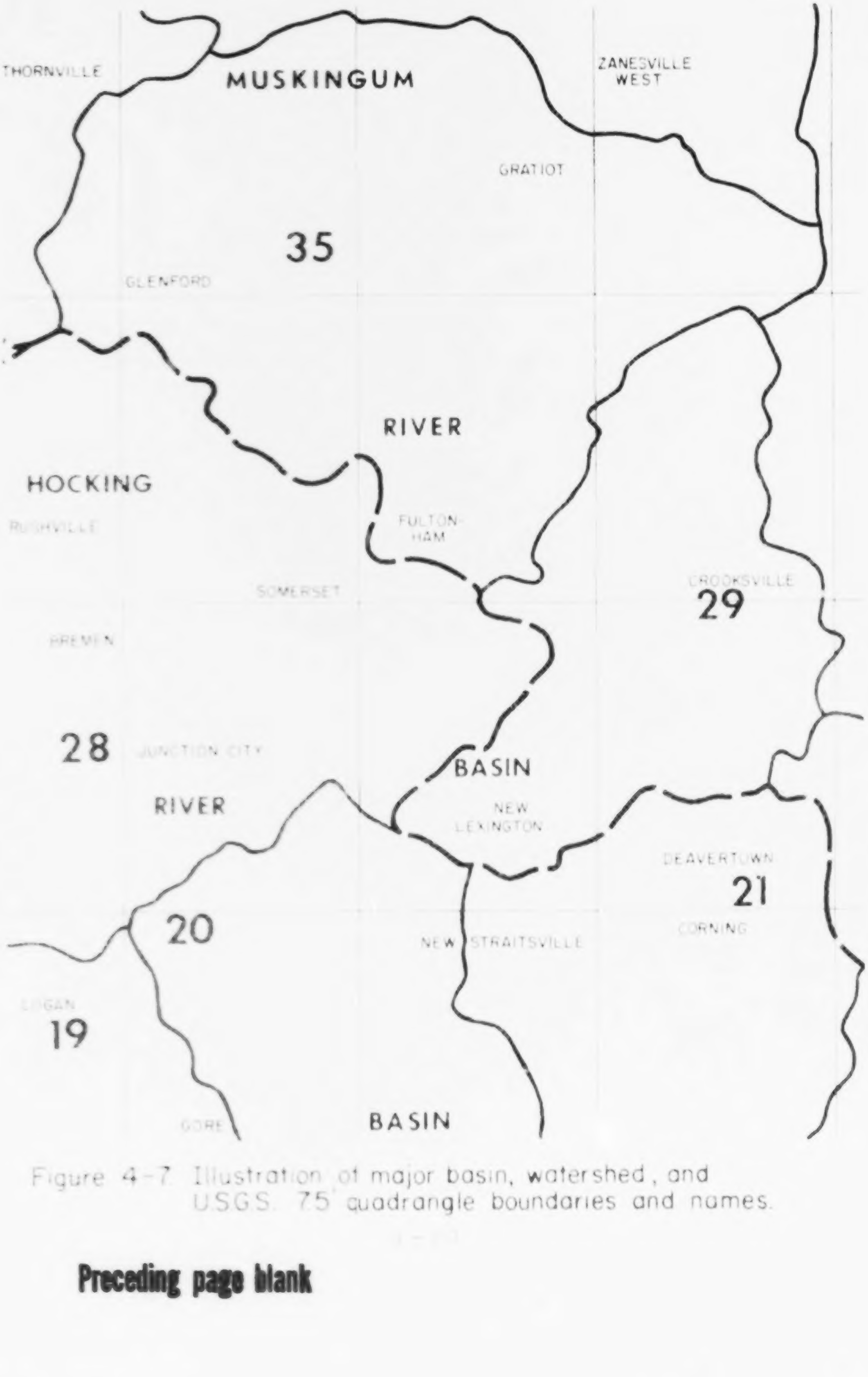

Figure 4-7. Illustration of major basin, watershed, and U.S.G.S. 7.5' quadrangle boundaries and names.

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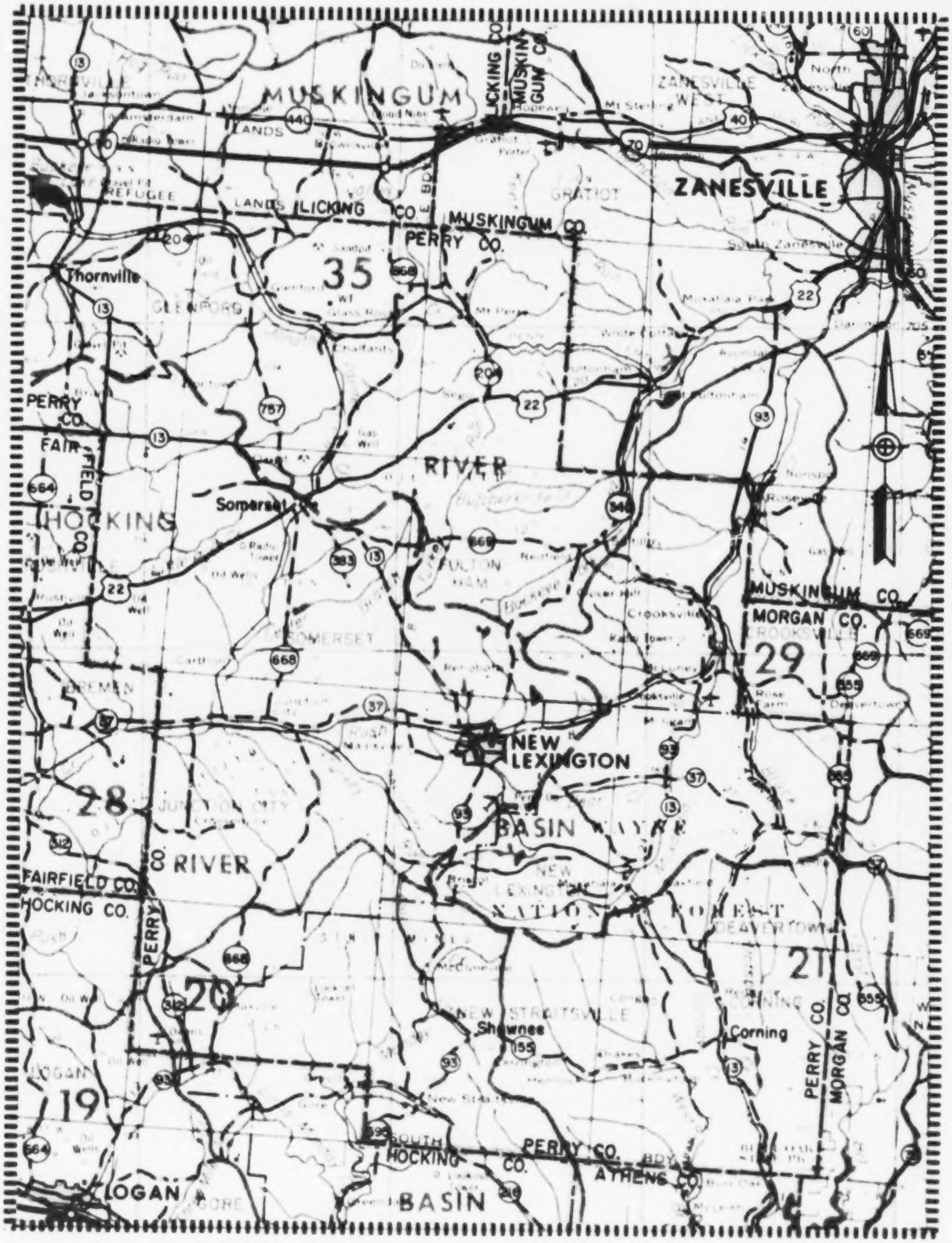

Figure 4-8. Illustration of figures 4-4, 4-5 and 4-7 superimposed.

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green overlay will be of major importance throughout the remainder of the study and in most subsequent, more-detailed, implementation studies.

Following development of the basin-module breakdown shown on the previous overlay, stream sampling and flow measuring stations can be designated and plotted on a separate overlay, such as the one shown in Figure 4-9. As can be seen, the only practical use of such an overlay is for presentation of the points in a separate color. The overlay without the base mapping it relates to is useless. Figure 4-9 shows the location and numbers of the points, which may represent either existing data collected in previous studies or points newly assigned for data collection in the statewide abatement study. The points on the overlay may also distinguish between stream stations and pollution point sources, if that is desired.

The sample point overlay can be added to the developing composite map after all points have been plotted and numbered. Figure 4-10 illustrates the composite as it stands at this stage - base map in black, streams in blue, modules in green, and sample points in purple.

As the water quality sampling program is completed and stream conditions are defined and grouped, general water quality can be illustrated on the base mapping utilizing various color overlays. Depending upon the nature of the pollutants and the study itself, the number of different water quality classes will vary. The example cited here utilized three distinct classes - "hot" for seriously degraded streams, "marginal" for streams with borderline water quality, and "cold" for streams with acceptable water quality. Each of these classes can be represented by a separate color overlay showing the locations of such sub-watershed areas. The overlay in Figure 4-11 illustrates "hot" areas and highlights streams polluted in their headwaters which subsequently pass through downstream areas where drainage is of marginal or acceptable quality. The yellow overlay, Figure 4-12, delineates sub-watershed areas which produce waters of "marginal" quality and highlights streams which are "marginal" in quality near their headwaters and pass through downstream areas of acceptable water quality. "Cold" watershed areas, those with acceptable quality, are not colored on the final mapping. In this manner, only "hot" and "marginal" areas are highlighted on the maps, and less attention is focused on the "cold" area.

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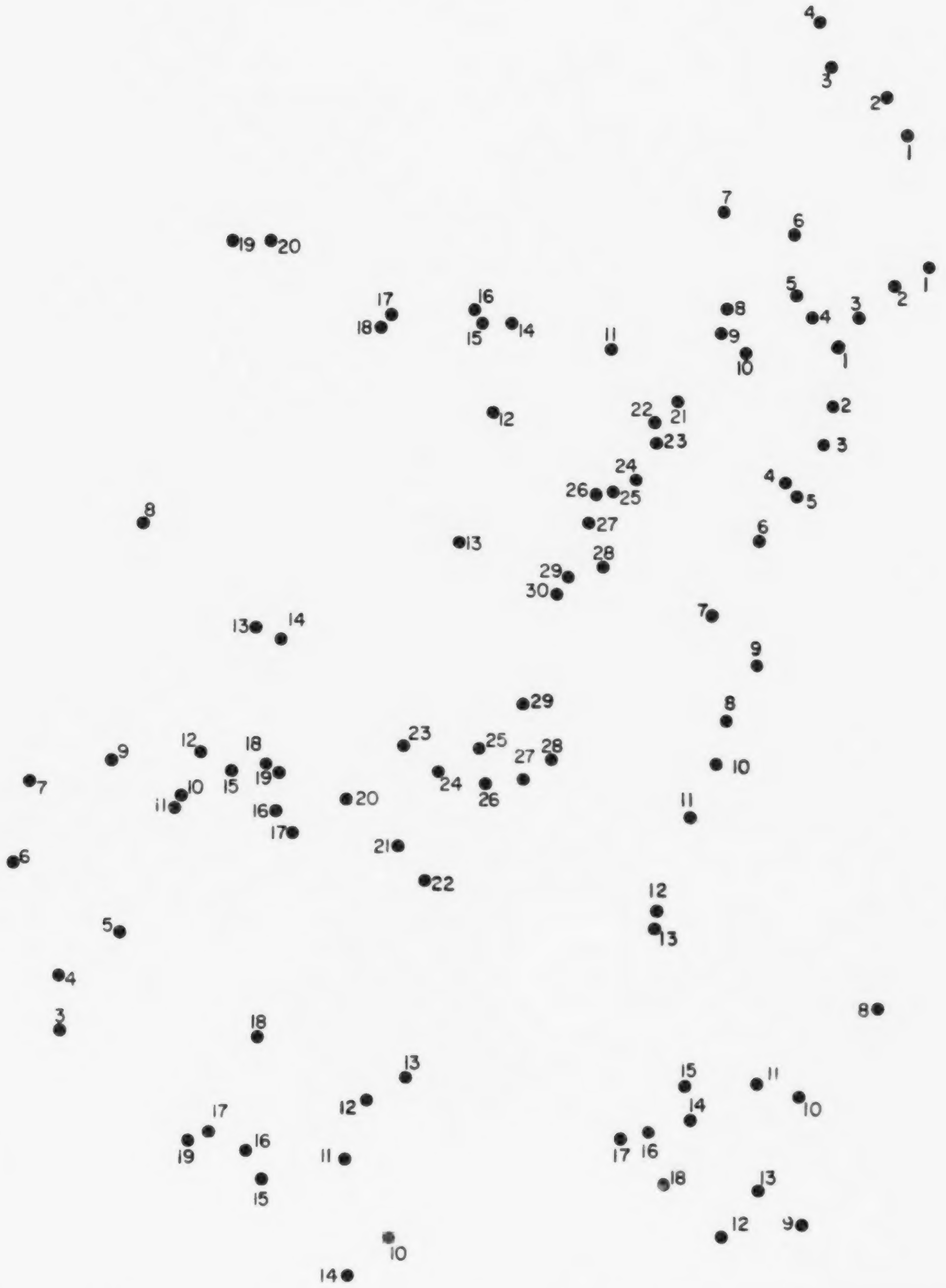

Figure 4-9. Illustration of sampling & flow measuring stations.

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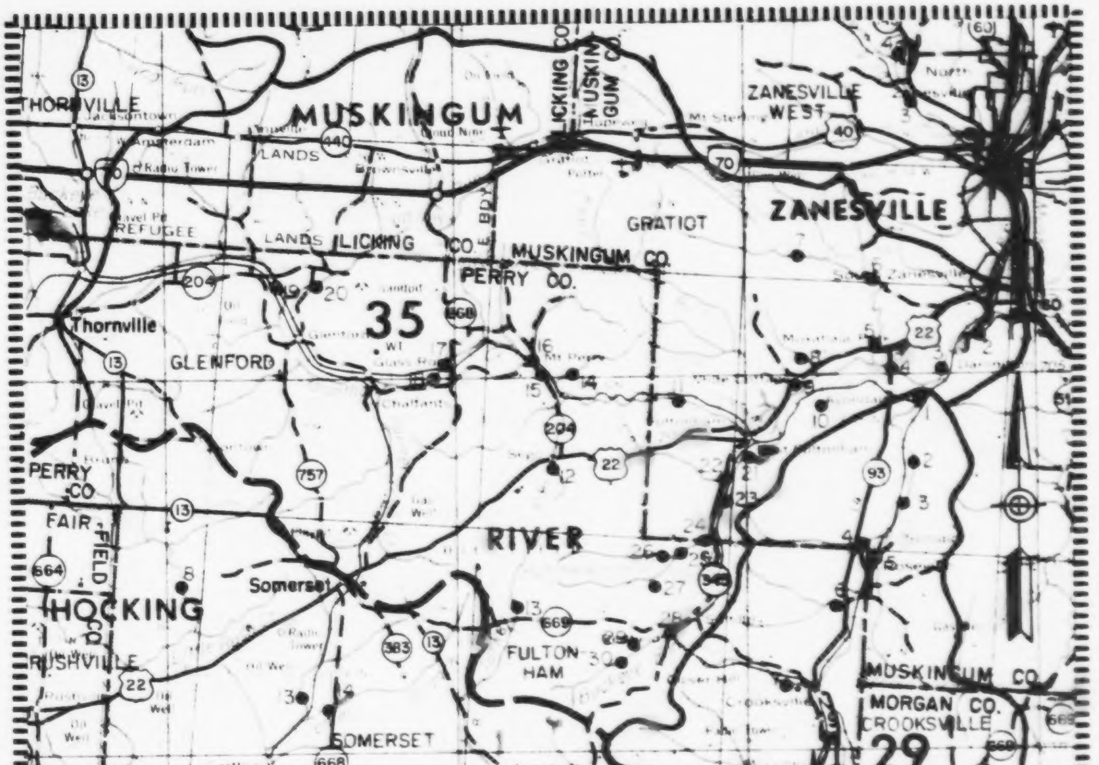

Figure 4-10. Illustration of figures 4-4, 4-5, 4-7 and 4-9 superimposed.

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Figure 4-[illegible] Illustration of hot areas and severely polluted stream within cold area

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To illustrate water quality findings of the statewide abatement study, these color overlays can be added to the developing composite map as illustrated in Figure 4-13. The composite at this state presents complete findings of the water quality phase of the study - modular breakdown, sample point delineation, and stream quality breakdown. Subsequent findings pertaining to the mined lands inventory can be added to this composite or illustrated without the water quality overlays.

The overlay illustrated in Figure 4-14 represents the generalized findings of the inventory of surface mined lands. The mined areas as shown on the overlay represent a summary or generalization of the actual surface mines delineated on the photomaps or topographic quadrangles utilized in the field. The final overlay, Figure 4-15, represents the generalized findings of the second portion of the mined lands inventory - underground mine delineation. These two overlays can be composited with other study findings excluding water quality to emphasize findings of the mined lands inventory portion of the study, as shown in Figure 4-16. They can also be composited with all other findings of the statewide abatement study, as shown in Figure 4-17.

Another important and highly desirable product of most of the statewide abatement planning surveys will be the photos or other maps of an appropriate scale upon which the mined lands and associated features have been delineated and classified. Such mapping will prove extremely useful in subsequent follow-up investigations of individual watersheds, sub-watersheds, or reclamation or abatement feasibility studies; and its usability can be enhanced by proper presentation of pertinent auxiliary mapping that would also be valuable. Figures 4-18, 4-19, 4-20, and 4-21 are samples of a typical "set" of mined land inventory mapping that would be developed, assuming in this case that aerial photographs were obtained on a scale of 1 cm. = 240 m. (1 in. = 2000 ft. - the same scale used on USGS 7.5 minute topographic quadrangles). Figure 4-18 is simply an untouched portion of one of those 7.5 minute USGS maps. Its inclusion is necessary because it is sometimes difficult to interpret topography from aerial photographs at such a large scale.

Figure 4-19 is an untouched segment of a typical aerial photo-

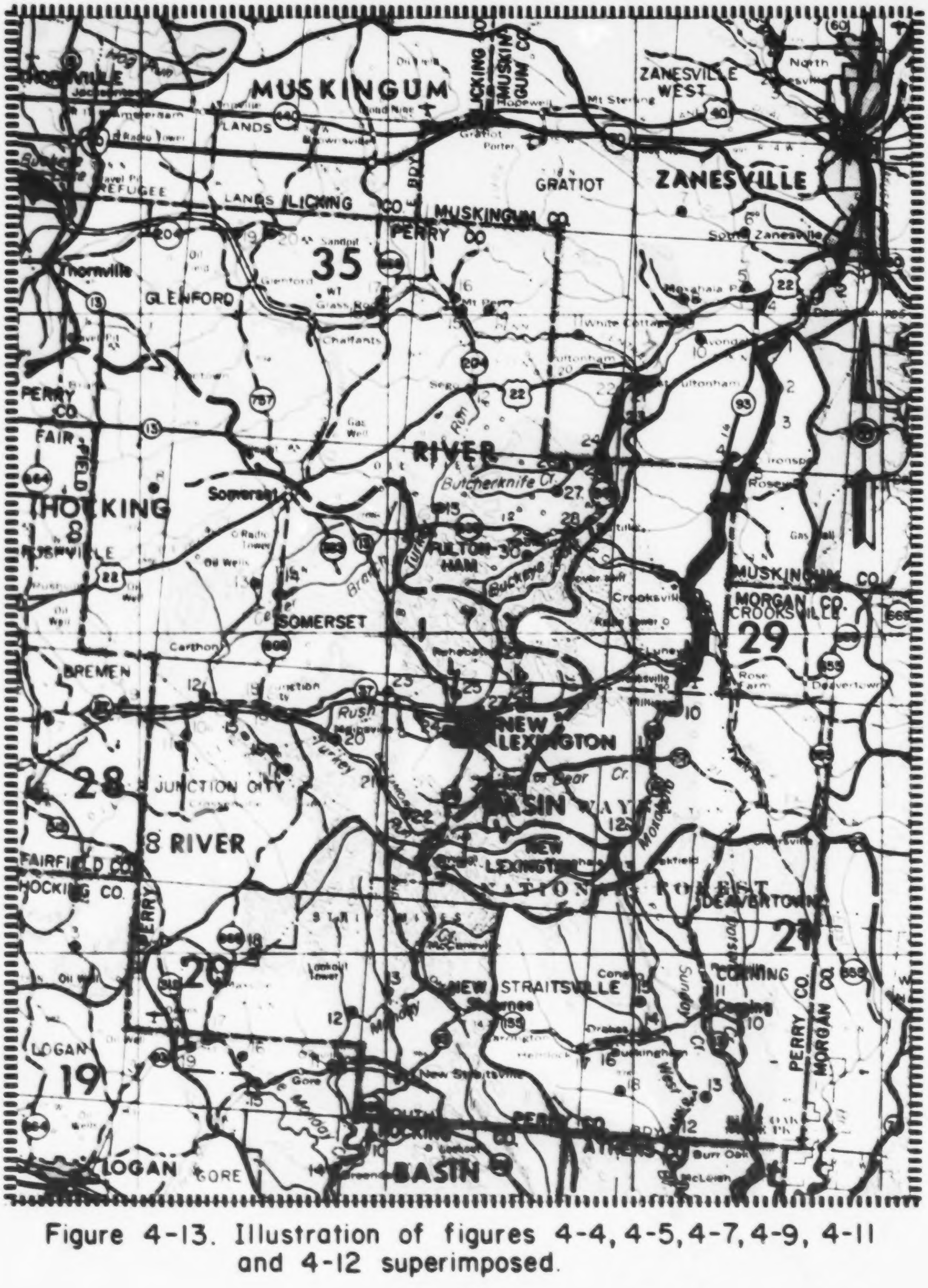

Figure 4-13. Illustration of figures 4-4, 4-5, 4-7, 4-9, 4-11 and 4-12 superimposed.

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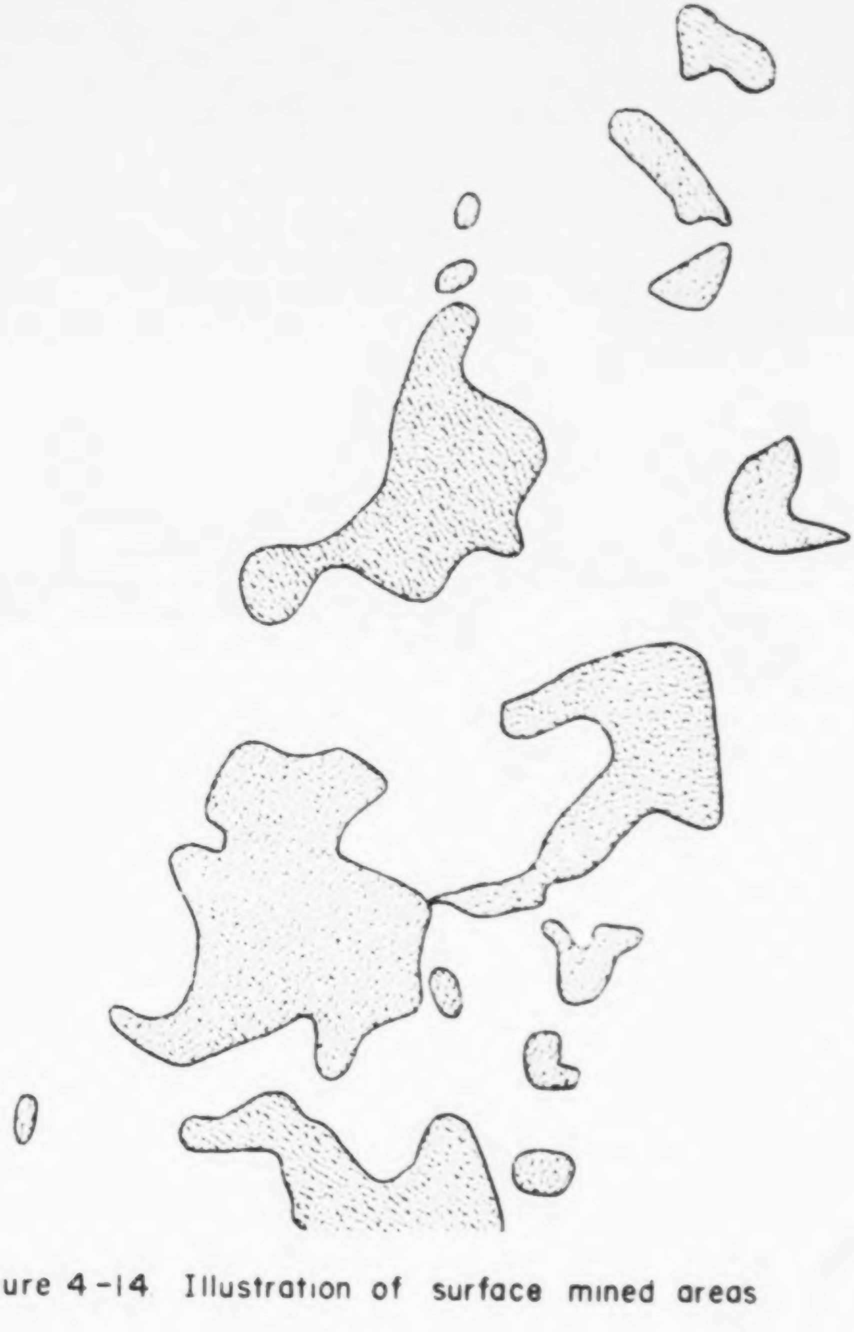

Figure 4-14 Illustration of surface mined areas

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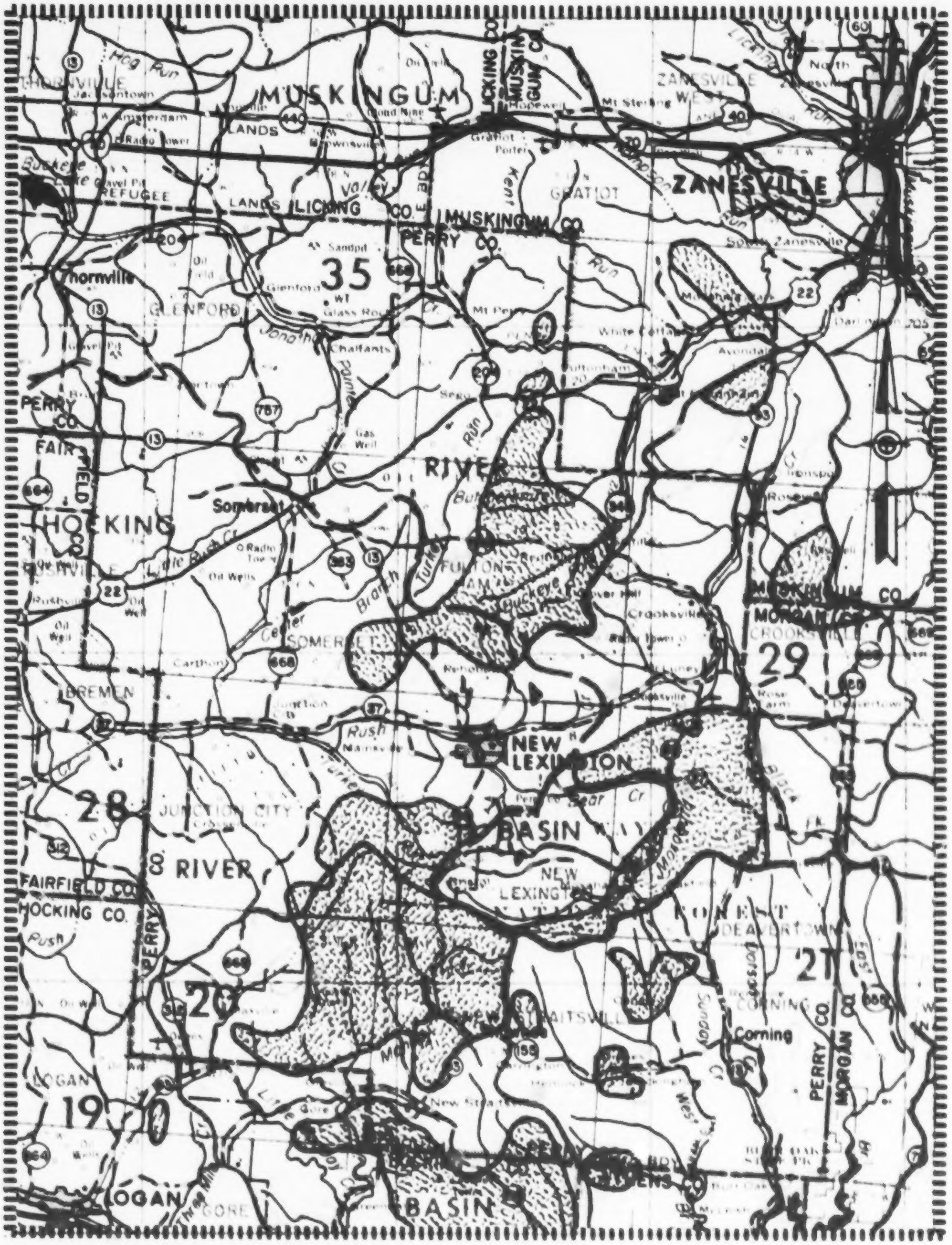

Figure 4-16. Illustration of figures 4-4, 4-5, 4-7, 4-14 and 4-15 superimposed.

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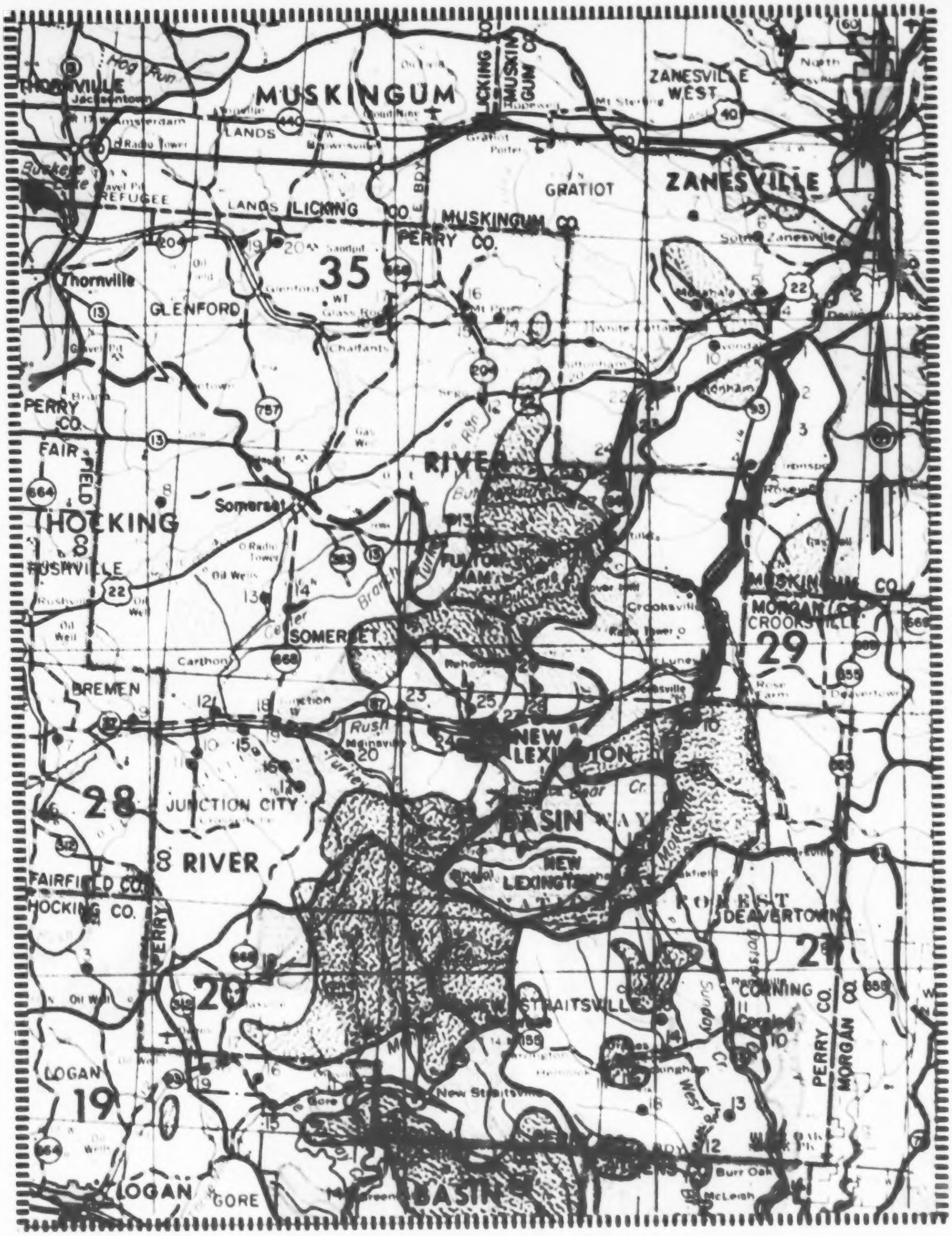

Figure 4-17. Illustration of composite map.

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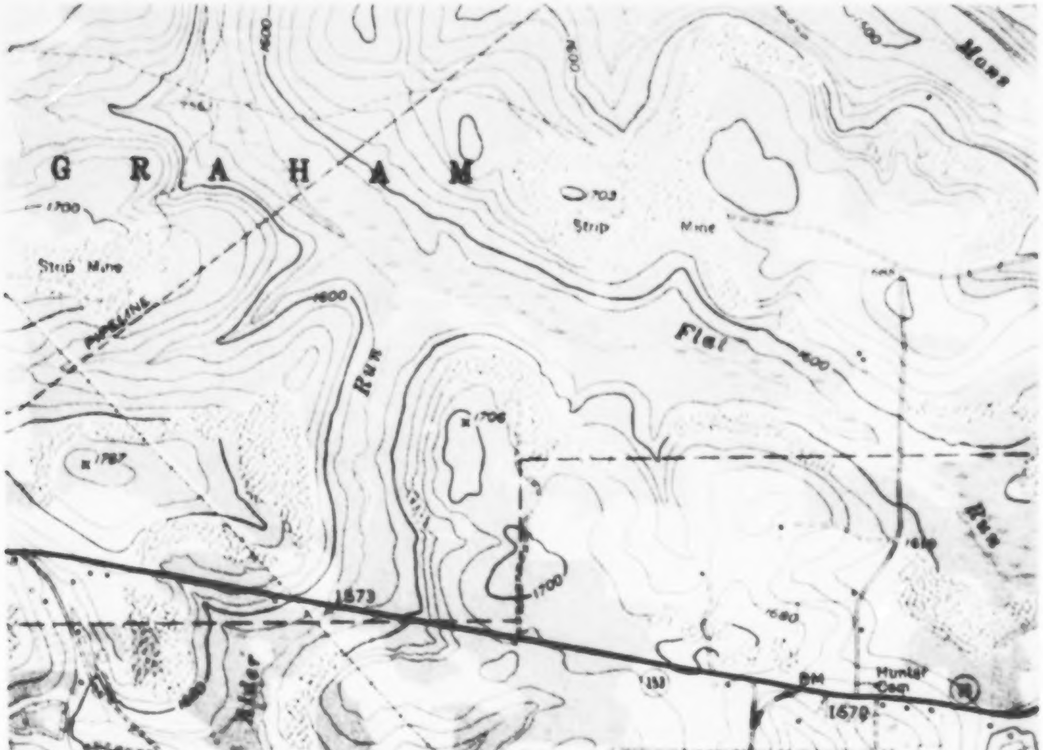

Figure 4-18. Illustration of 7½' U.S.G.S. Quadrangle.

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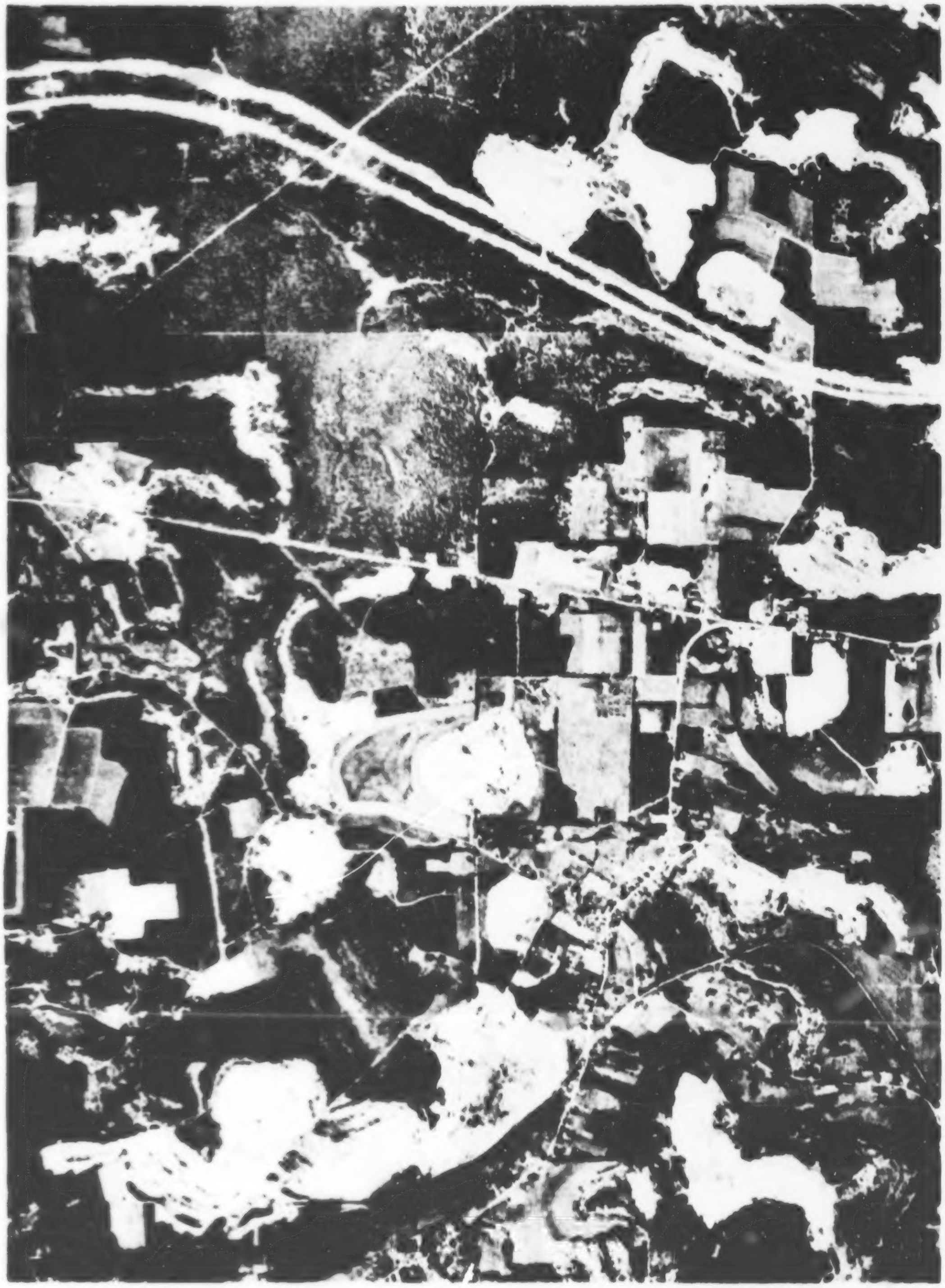

Figure 4-19. Illustration of aerial photography.

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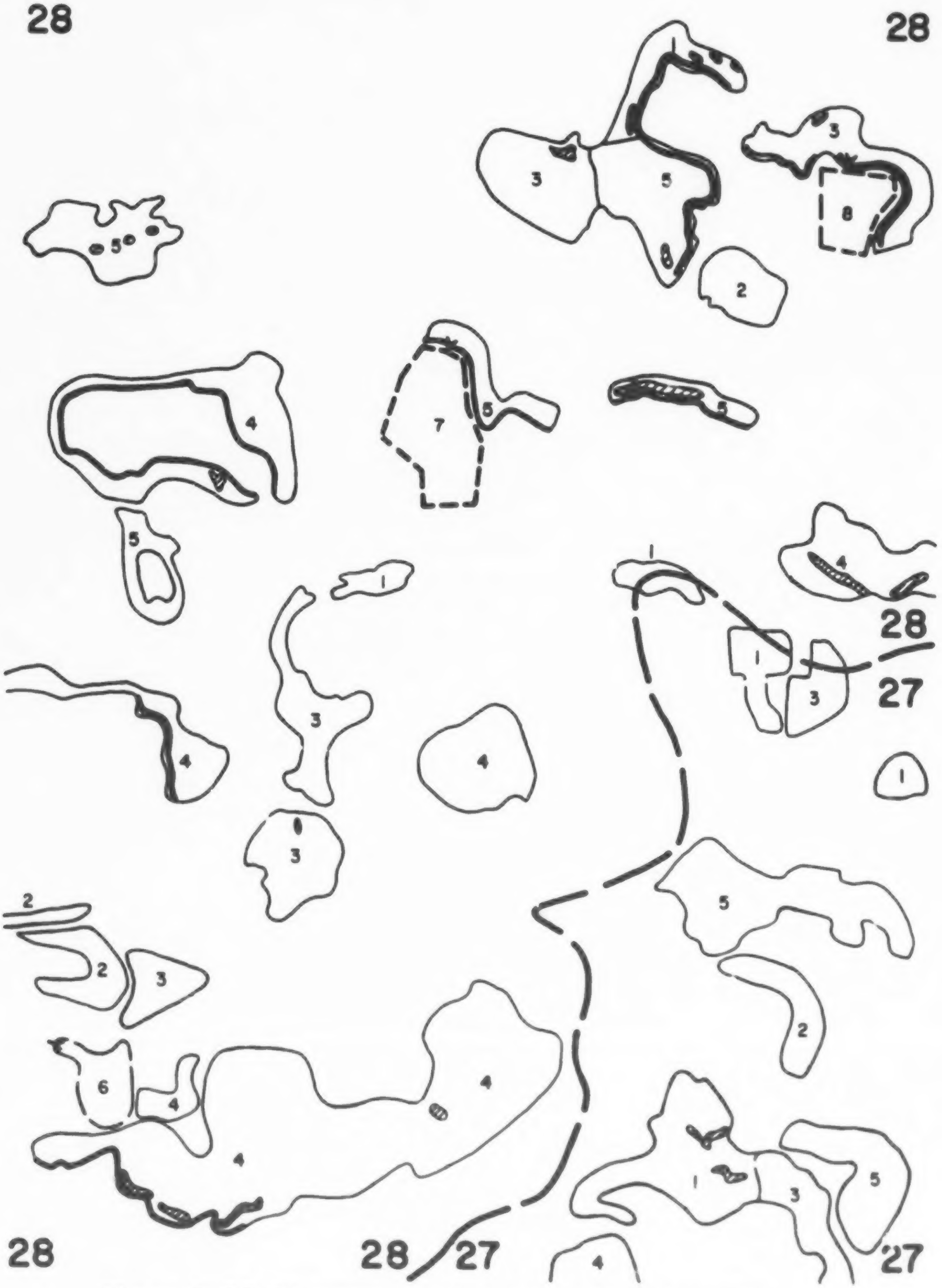

Figure 4-20. Illustration of overlay depicting mine features & watershed boundaries.

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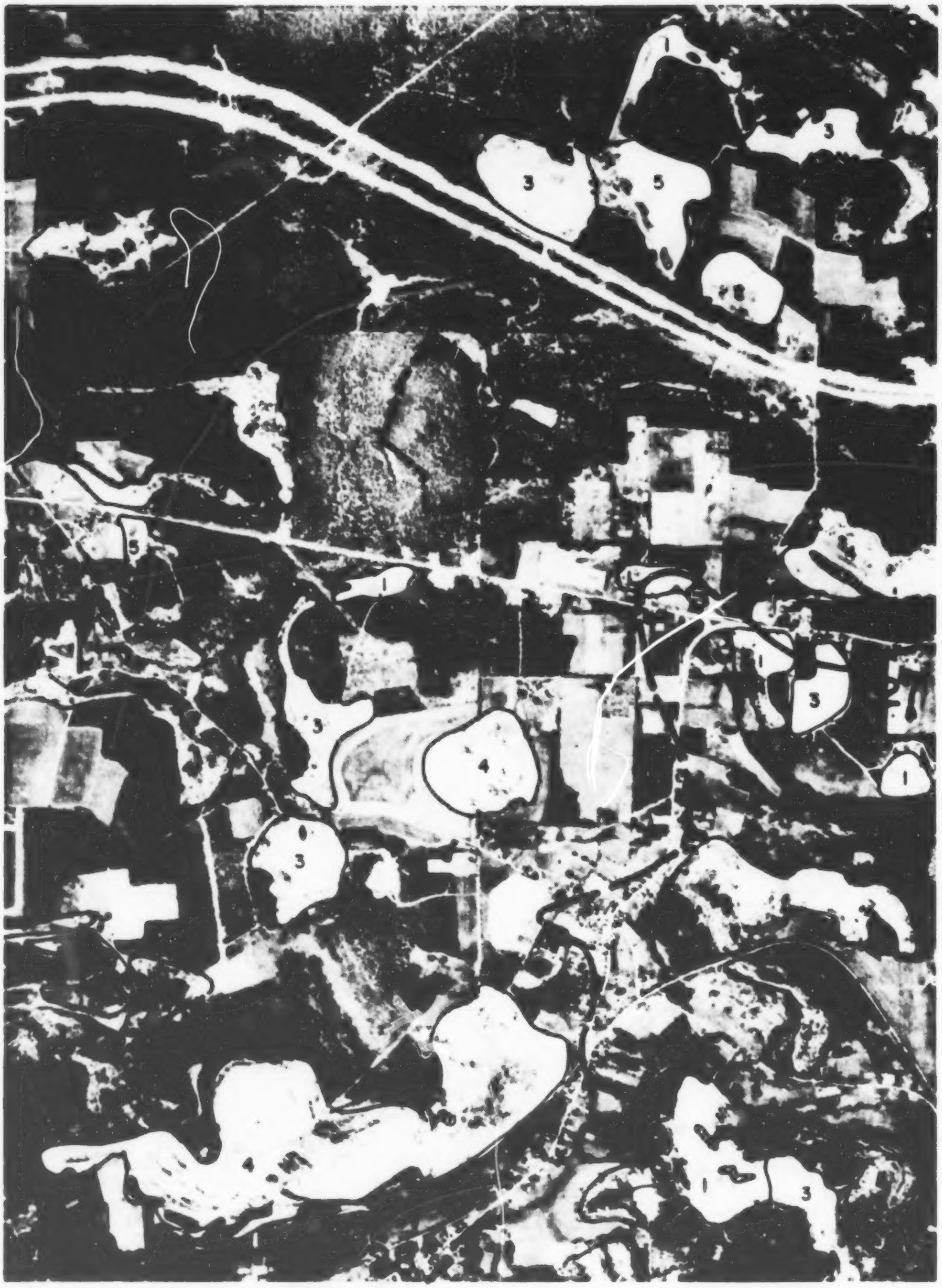

Figure 4-21. Illustration of composite aerial photography and mine features.

Photomaps of the type illustrated here have a multitude of potential uses. Agencies and organizations at all levels can utilize the photomaps for any of the following purposes:

1. Identification and categorization
   - Developed areas - urban, residential, industrial, commercial, and agricultural
   - Vegetation - type, density, extent
   - Transportation facilities - highways, roads, trails, railroads, waterways, airports, canals
   - Geology - faults, fracture traces, subsidence areas
   - Surface drainage - watershed divides, drainage areas and patterns, streams, rivers, ponds, lakes
   - Major landforms - mountains, valleys, flood plains
   - Surface features - erosion gullies, ditches, landslides, timbering, forest fire sites, pollution kills, seepage areas, construction
   - Mining - surface mines, surface evidence of underground mining, reclamation techniques, status of revegetation, water diversion, highwalls, refuse piles, spoil banks, mine impoundments, flooded final cuts, sediment basins
2. Analysis and interpretation
   - Mine reclamation requirements
   - Potential stream sampling points
   - Future development trends and land uses - mining at new sites or reaffected sites for same or different minerals, residential, commercial, industrial, recreational

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- Wildlife refuge and sport fisheries locations
- Woodland timbering reserves
- Potential water supplies, dam and reservoir sites
- Areas of high erosion or flooding potential

Addition to the photomaps of composites showing geologic units, structural geology, soils mapping or surface contours can greatly amplify the amount and types of data available, substantially increasing the value and usability of the photomaps.

Several additional illustrations are included to point out the potential future updating of the mining activities and conditions delineated on the aerial photographs. Figure 4-21 shows the base photomap with mined lands defined and classified as would originate in a typical statewide abatement study. Figure 4-22 illustrates the first up-date of the Figure 4-21 photomap. Note that it is possible to show changes in mined land classifications, surface and underground mine permit boundaries, areas which have subsequently been completely reclaimed, requiring no further efforts or attention. Figure 4-23 then shows a second up-dating of the information shown in Figure 4-21. Again it is possible to delineate changes in mining activity, mine conditions, and boundaries for both surface and underground sites.

Figure 4-22

LEGEND

CLASSIFICATION OF MINED LANDS

1 - ACTIVE SURFACE MINE
2 - COMPLETELY RECLAIMED
(OCCASIONAL WORK REQUIRED)
3 - MINOR RECLAMATION EFFORT REQUIRED
4 - MODERATE RECLAMATION EFFORT REQUIRED
5 - EXTENSIVE RECLAMATION EFFORT REQUIRED
6 - REFUSE PILE
7 - ACTIVE UNDERGROUND MINE
8 - INACTIVE UNDERGROUND MINE
③ - CLASSIFICATION CHANGE — 1st UPDATE

——— ———	- WATERSHED BOUNDARY LINE
〰〰〰	- SURFACE MINE HIGHWALL
———————	- SURFACE MINE LIMIT
—— —— ——	- REFUSE BOUNDARY LINE
▨	- MINE IMPOUNDMENTS
3	- MINE CLASSIFICATION NO.
27	- WATERSHED IDENTIFICATION NO
≻	- UNDERGROUND MINE ENTRY
— — — — — —	- UNDERGROUND MINE BOUNDARY LINE
······················	- SURFACE MINE BOUNDARY LINE
2	- COMPLETELY RECLAIMED (No Work Required)

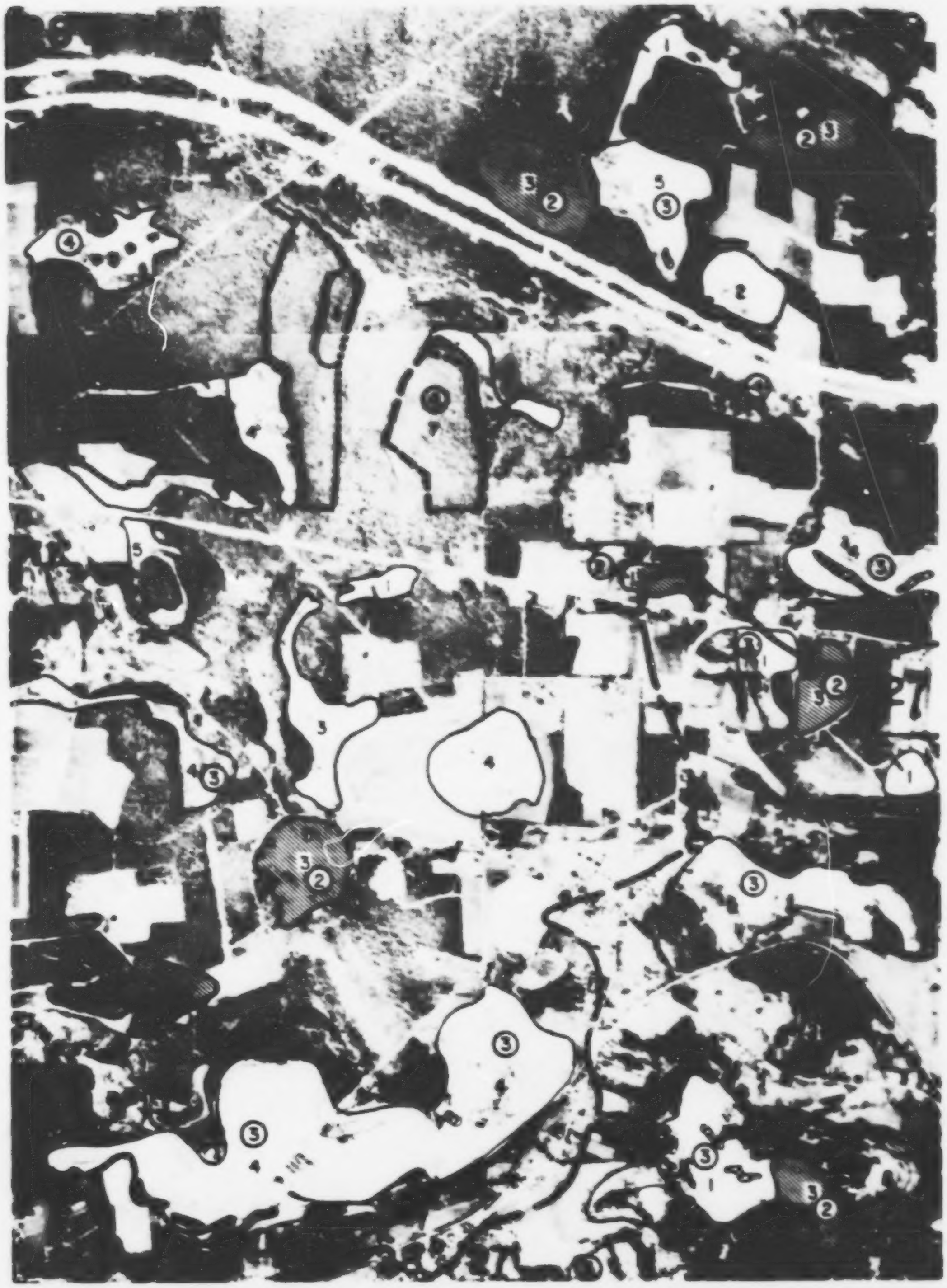


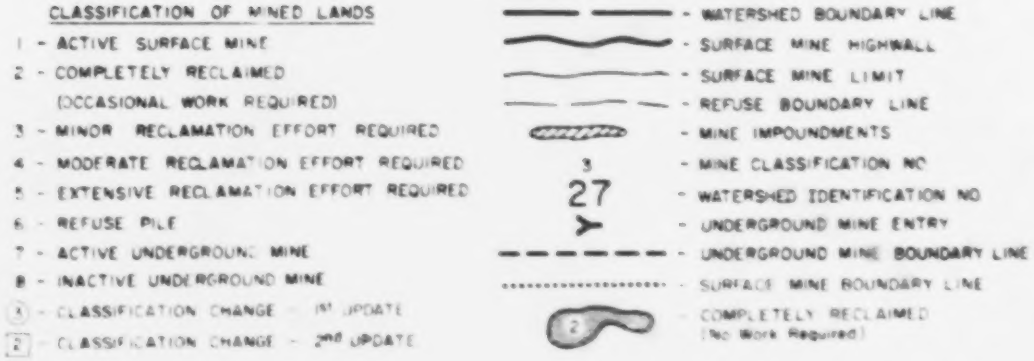
Figure 4-22. Illustration of feasible method of updating mining. (First update)

The actual up-dating of mining activities could be performed on single quadrangles or groups of quadrangles in subsequent implementation stages, which are discussed in the next chapter. The up-dating could also be accomplished as a statewide program, permitting all photomaps to be maintained at the same level of accuracy in terms of up-dating. Such programs could be conducted annually, every two years, five years, ten years, etc., depending upon the size of the study area and the funds available for such activities.

Potential uses of such up-dated mapping would be greatly increased. Many local, state, and federal planning and action agencies perform studies in which they must duplicate the effort of delineating up-to-date mining activities and conditions for specific areas. With a complete set of up-dated aerial photomaps, much of this duplicate effort, and the use of funds it represents, could be eliminated.

Figure 4-23

LEGEND


CLASSIFICATION OF MINED LANDS
1 - ACTIVE SURFACE MINE
2 - COMPLETELY RECLAIMED (OCCASIONAL WORK REQUIRED)
3 - MINOR RECLAMATION EFFORT REQUIRED
4 - MODERATE RECLAMATION EFFORT REQUIRED
5 - EXTENSIVE RECLAMATION EFFORT REQUIRED
6 - REFUSE PILE
7 - ACTIVE UNDERGROUND MINE
8 - INACTIVE UNDERGROUND MINE
3 - CLASSIFICATION CHANGE - 1st UPDATE
2 - CLASSIFICATION CHANGE - 2nd UPDATE
- WATERSHED BOUNDARY LINE
- SURFACE MINE HIGHWALL
- SURFACE MINE LIMIT
- REFUSE BOUNDARY LINE
- MINE IMPOUNDMENTS
3
- MINE CLASSIFICATION NO
27
- WATERSHED IDENTIFICATION NO
- UNDERGROUND MINE ENTRY
- UNDERGROUND MINE BOUNDARY LINE
- SURFACE MINE BOUNDARY LINE
2
- COMPLETELY RECLAIMED (No Work Required)

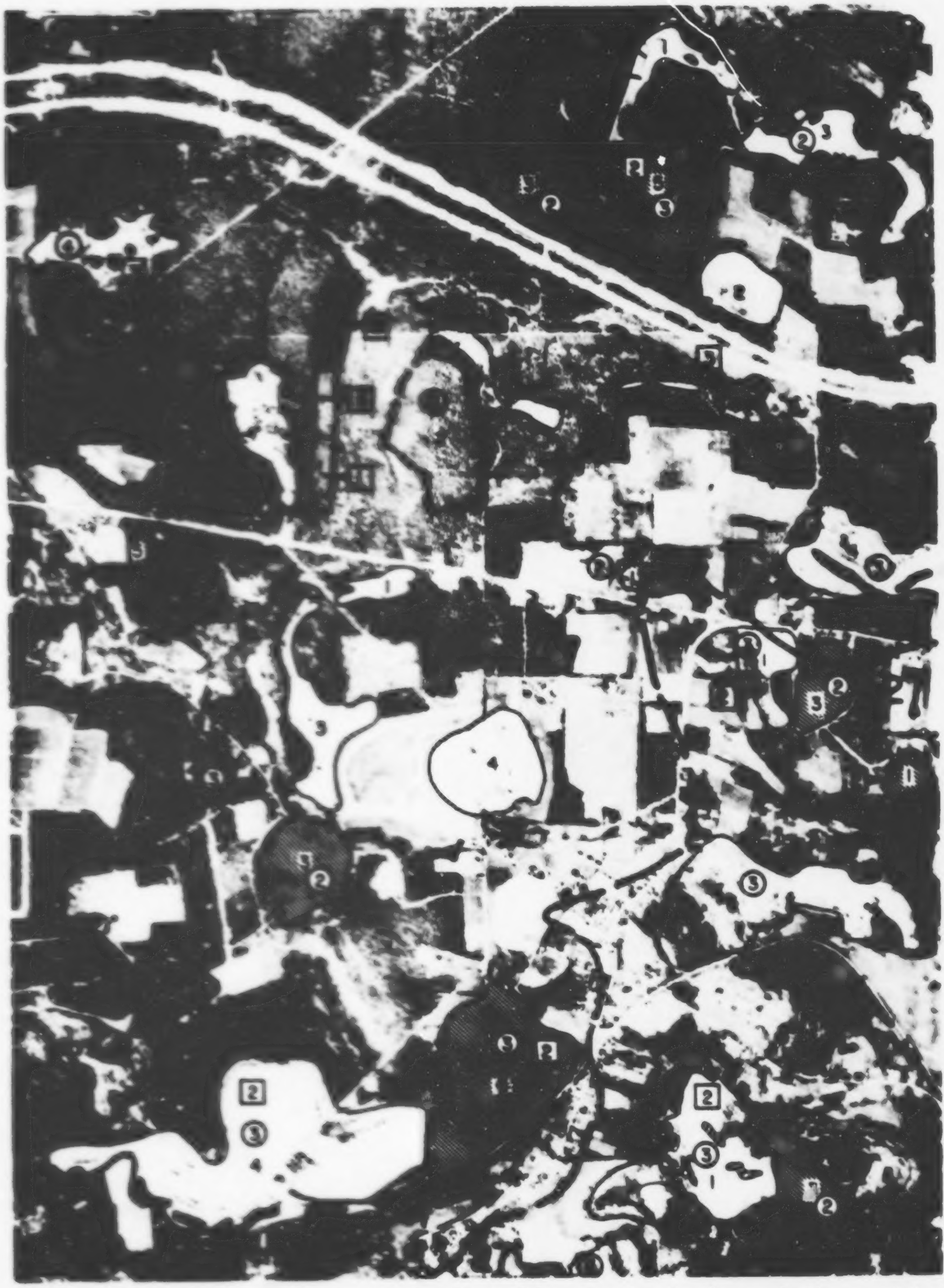


Figure 4-23. Illustration of feasible method of updating mining. (Second update)

CHAPTER 5

IMPLEMENTATION

IMPLEMENTATION

Successful completion of a statewide mined lands inventory is a pre-requisite to proper planning and performance of watershed feasibility studies and subsequent abatement or reclamation programs. From this initial statewide inventory program, priorities are established for future feasibility studies. A wealth of information assembled in the inventory is also available and relevant to the goals of the feasibility study. Therefore, the statewide inventory and subsequent watershed feasibility studies should be viewed as complimentary and interdependent, although they are separate operations.

The specific objective of the watershed feasibility study is to obtain the information necessary to implement a successful surface mine reclamation and mine drainage abatement program in the subject watershed. Such a watershed feasibility study should:

- Determine the extent and severity of mine drainage in the subject watershed's main stream and tributaries;
- Evaluate aquatic and terrestrial ecosystems and the impacts of water quality upon them;
- Assess baseline and socio-economic conditions and variations throughout the study area;
- Conduct a pollution source inventory to locate and measure specific discharges associated with past and present mining;
- Determine the impact of mine drainage on the primary receiving stream;
- Recommend remedial measures for each significant source of pollution which can be reduced or eliminated by current technology;
- Attempt to distinguish between the pollution loading contributions of active and inactive mines and between surface and underground mines;
- Assess the future mining potential within the study area;

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- Establish the cost and cost effectiveness of remedial measures, including a ranking of the measures according to recommended priority; and

- Develop and recommend an "abatement plan" for the watershed.

Necessary to the implementation of a successful abatement program is the careful, thorough analysis of the various available reclamation and abatement alternatives. The planning procedure and its execution must insure that abatement and reclamation processes yield the highest possible benefit for every dollar expended. Use of a specific, effective series of planning phases allows isolation of logically related, interdependent actions, and simultaneously provides a means of gauging overall progress. This chapter of the report deals with methodology best suited for use in planning and conducting an abatement feasibility study and subsequent reclamation or abatement work at pollution sources. Tasks are discussed in the logical order of performance.

TASK 1 - GATHER, MAP AND EVALUATE EXISTING DATA

The initial project step should be the assembly of all known information on water quality, climatology, geology and mining that might help to reduce the scope of the reconnaissance program. Much of this information presently exists and can be obtained readily.

Water Quality Data

The state department or agency dealing with natural resources will be a primary source of water quality information. This data will be available from sources such as:

- Statewide abatement priority planning programs;

- Water inventories performed by various local, state, or federal agencies concerned with environmental protection, natural resources, health, stream quality, forestry, fisheries, or conservation;

- Pollution point source sampling conducted by or in conjunction with the U. S. Environmental Protection Agency or its predecessor, the Federal Water Pollution Control Administration (FWPCA);
- EPA's computerized STORET data system;
- USGS stream gauging stations' records;
- Watershed or river basin management agencies such as the Ohio River Basin Sanitation Commission (ORSANCO), the Interstate Commission on the Potomac River Basin (INCOPOT), the Susquehanna River Basin Commission (SRBC), Yellowstone Basin Water Users Association, and the Powder River Basin Resource Council.

All water quality data obtained should be coded in some logical system and plotted along with water quality data previously gathered during the mined lands inventory. A uniform data sheet can be developed, and all relevant water quality data for each sample point can be transferred from original data sources. This combined mapped data should then be carefully scrutinized and utilized to establish an initial feasibility study reconnaissance program.

Geology and Soils

Locations of mineable mineral resources, outcrops, configurations, dimensions and character of the mineral deposits, and their pollution-producing capabilities should be determined, where possible, from available geologic information. This information will be particularly useful in the water sampling phase, since the program's emphasis can be shifted away from areas of little pollution potential and concentrated in areas which are major producers of mine drainage.

Similar efforts should be undertaken to ascertain soil types and distribution throughout the study area. Soils mapping and analysis data, which can be gathered from sources such as the Soil Conservation Service, is important for proper assessment of reclamation and future land use capabilities in the study area.

Mining

All available data relating to mining within the watershed should also be gathered. Aerial photographs with up-to-date surface mine outlines and conditions, completed for the statewide abatement study, can be very useful when establishing water quality sampling programs, conducting field reconnaissances, and determining reclamation feasibilities. Information and mapping related to underground mines within the watershed should be obtained from the State's Bureau of Mines and from the U. S. Bureau of Mines. Additional underground mine maps may be available from local mining engineering firms, former or current mine operators, and local interviews, which can lead to previously unknown sources of underground mine data. Underground mining information is extremely critical to the project, since abandoned mines are frequently the major sources of mine drainage in a watershed. Successful design and implementation of underground mine pollution abatement projects depends on the existence of mine maps.

Ecology

All existing data pertaining to the aquatic and terrestrial ecology of the study area should also be accumulated. The distribution and diversity of plant and animal life in an area and their relationships to stream conditions are of particular interest. Also, the relationships between ecological factors and the presence, extent, and conditions of surface and underground mines in various portions of the study area should be assessed. Such analyses will be valuable in the final determinations of abatement and reclamation requirements and priorities.

Socio-Economic Conditions

Baseline socio-economic characteristics of various portions of the study area can also be important in determining reclamation and abatement priorities. Important characteristics include population trends, employment and housing characteristics, available social services, recreational facilities (characteristics, utilization statistics, economics), and aesthetics (air, water, land, accessibility, scenic quality). Additional socio-economic considerations around mined areas include public visibility, accessibility (proximity to major highways, urban areas, local airports), public land ownership of potential reclamation sites, present and future land uses, and general visual quality of various portions of the study area as evidenced by landscape diversity - landform variation, landscape pattern, water and vegetation.

TASK 2 - ESTABLISH RECONNAISSANCE PROGRAM

After available information on water quality, geology, and mining has been assembled, coordinated, analyzed, and digested, the sampling program requirements will be evident. Thus, a preliminary sampling program, aimed primarily at completing the water quality and mine drainage "picture" of the study area, should be established to confirm data obtained in previous studies and to fill any apparent gaps in that data. The statewide abatement planning study should have divided the study watershed into a number of subwatershed units or distinct hot, marginal, and cold areas (See Figure 4-23). This subwatershed system should be re-evaluated based upon analysis of data accumulated in Task 1, and then modified as necessary to provide the information required. Watersheds should be larger in lesser mined regions where geology and water quality data indicate that mine drainage is minimal. In heavily mined regions, watersheds should be kept small, to more accurately define mine drainage problems.

Once subwatersheds have been defined, initial sampling and measuring points can be established. Initial sampling should generally cover the entire watershed and consist of 50 to 75 stream sampling points.

TASK 3 - GATHER FIELD DATA

Water quality surveys should employ three basic sampling schemes - modular, repetitive, and point source - each with a specific purpose and scope in relation to the nature of the overall study. Modular sampling, employed for the first two sample runs, is designed to evaluate and categorize the subwatersheds or modules on a one-time-only basis. Three categories of modules can initially be defined as follows:

1. Hot - Significant sources of mine drainage pollution where intensified study will definitely be required.

2. Marginal - Modules within which additional sampling will be required before a hot or cold classification can be made.

3. Cold - Modules within which water quality is not severely degraded.

The first sample run will generally delineate hot, cold, and marginal areas, while the second sample run can be used to divide the "hot" areas into smaller workable units and to reclassify "marginal" units as either "hot" or "cold." Goals of the first sample run were partially achieved by sampling programs conducted during the statewide abatement study. The first sample run in this feasibility study should therefore emphasize verification and expansion of the statewide study's findings, while the second sample run can concentrate on characterizing hot and marginal areas.

Water quality sampling programs should primarily utilize "grab" sampling methods. This enables collection of a large number of samples over wide areas in a relatively short time period while providing data that meets the requirements of the feasibility study. Sampling, flow measurement, and flow adjustment procedures for grab sampling are discussed in detail in the previous chapter.

Once the watershed has been adequately characterized and flows have been adjusted, a series of repetitive sample stations should be designated. These stations can be strategically located throughout the watershed to enable periodic assessment of stream flow and water quality conditions during the study. The data obtained at these stations can also be used to document the success of future reclamation and abatement projects.

TASK 4 - INTENSIFY STUDY ON REDUCED SCOPE AREAS

The purpose of this task is to isolate pollution sources within classified hot modules. This is best accomplished by point source sampling, using "grab" samples.

Sample crews should walk streams within these hot modules, collecting water samples and stream flow measurements at each pollution source or tributary stream. Each sample point should be flagged, numbered, mapped, and described. Surface mines and the outcrops of potentially polluting mineral deposits or seams should be investigated, and abandoned drifts, shafts, airways, slopes, caved areas, seepage areas, and refuse areas should be located and mapped. Since this should not be a long-term sampling program, most pollution sources need be sampled only once or twice. However, the modular and point-source sampling results from this task, combined with data obtained in previous studies, will be sufficient to accurately identify major pollution sources.

TASK 5 - DETERMINE RELATIVE MINE DRAINAGE CONTRIBUTIONS (ACTIVE VS. INACTIVE)

In some areas and mining industries, it has been reported that active mining operations are serious sources of mine drainage pollutants despite existing regulations and guidelines. To determine whether or not this occurs within the study area, an attempt should be made to distinguish between active and inactive as well as surface and underground pollution sources and their relative sizes. The extent of active mining can be determined by examining the mine drainage discharge permits held by the appropriate state agency and permit information submitted to the federal government through NPDES permit program. These permit applications usually contain information related to mine discharges (flow and quality), treatment facilities, mineral data, and location, type and extent of mining activity.

Existing estimating methods and techniques used to separate active, abandoned, surface and underground mine drainage can be utilized during prosecution of this task. The best currently available method involves simple observations of flow and water quality measurements of mine discharges.

TASK 6 - IDENTIFY DATA GAPS

All information obtained during previous study segments should be reviewed to identify data and information gaps (with primary emphasis on mining and water quality data). This assessment can be conducted by establishing what specific information will be required for future tasks, including determination of base conditions and plan formulation. The required information should then be identified and recommendations provided for its acquisition.

TASK 7 - DETERMINE RECLAMATION AND ABATEMENT FEASIBILITY

Preliminary feasibility evaluations of abating each pollution source defined in the preceding steps should generally be completed in the office, after all obtainable data and pertinent information has been collected, plotted and studied.

Specific and regional geology and hydrology at pollution sources should be studied and mapped, where possible. Local residents involved in or having knowledge of the local mining industry can be interviewed for information pertaining to old mining sites, methods, drainage, and other important facts. Tax maps, mine permit information, aerial photographs, weather bureau records, mining records and soils information should be obtained and studied.

United States Geological Survey 7½' topographic quads can be enlarged to 1 cm. = 120 m. (1 in. = 1000 feet) scale for each hot module or potential abatement area. These enlargements serve as the base for the "Mini-Mine Development Drawings," which can be used extensively in later work

Water quality data combined with all other accumulated information provides the basis for preliminary evaluation of hot modules. This preliminary evaluation makes it possible to determine potential abatement areas and to establish some general priorities among them based on such factors as general hydrology, geology, ecology, socio-economic conditions, present mining status, sources of pollution, and feasible abatement methods. From this preliminary priority ranking, a schedule can be established for intensive field reconnaissance by a geologist or other reclamation specialist in each potential abatement area, using the Mini-Mine Development Drawings (Scale 1 cm. = 120 m.). Draftsmen can plot all sample station locations, mineral structure contours and outcrops, faults, underground mine workings, drifts, air shafts, surface mines and active mining permits They can also label roads and towns and list property owners for each area. This mapping should be periodically updated with any new information on existing topography, seepage areas, refuse areas, surface mine areas, mine entries, and air shafts Analysis of field reconnaissance information, Mine Development Drawings, and water quality data will determine whether abatement work of some type is feasible and practical in each area. The latest abatement techniques should be considered and plans should be finalized for each area with emphasis on the greatest amount of abatement for the lowest cost. All available and feasible abatement techniques must be considered for recommendation, including the following:

1. diversion of surface water around surface mines and underground mine roof fractures;
2. stream rechanneling to retain good quality water in stream beds;
3. backfilling;
4. soil treatment and planting on unvegetated surface mines;
5. surface treatment or removal of refuse piles, storage areas, roadbeds;
6. underground mine sealing to prevent discharge;
7. surface sealing above underground mines to prevent water influx;
8. grouting, slurry trenching, daylighting, clay liner construction;
9. use of other industrial or extractive waste products for surface treatment to neutralize surface water percolating

through surface mines;
10. use of fly ash, sewage sludge, or other industrial or mining waste products to augment vegetative survival;
11. treatment of effluents.

TASK 8 - ASSESS FUTURE MINING POTENTIAL

The potential for future mining in the watershed should be assessed in depth. Much information currently exists on which to make judgments in this area. Past and present work in the specialized field of the particular extractive industry under study frequently presents or requires judgments and projections of this nature. Establishing contacts with federal and state agencies, officials who deal with or represent the mining industry, corporate officials, and owners from within the watershed can help in developing these estimates.

Special attention should be given to defining mineable mineral reserves on a gross, planning basis, with emphasis on the possibilities and potentials of new mines reopening or reaffecting existing abandoned mines. If at source pollution abatement can be accomplished by making active miners responsible for pollution emanating from abandoned mines affected by their new mining, much more abatement can be achieved at much less cost (concurrent reclamation).

Permit applications in the hands of federal, state, and/or local governments provide some information on reserves, current mining operations, and in some instances, their future mining plans. Contact should also be made with miners currently operating in and near the watershed to attempt to establish the mining potentials of the area as well as their future mining plans.

TASK 9 - COMPUTE COST AND COST EFFECTIVENESS

Construction costs and benefits should be estimated for each recommended abatement project based on the costs and benefits of abatement as established in previous state and federal studies, such as The Appalachian Regional Commission's Analysis of Pollution Control Costs and other relevant publications on reclamation and abatement.

The cost effectiveness of a mine drainage reclamation or abatement project is the cost in dollars of eliminating each pound of pollution emanating from the subject site. Cost effectiveness values can be obtained by dividing the reclamation or abatement cost by the pollution load attributed to the pollution source. The computed cost effectiveness values should then be analyzed along with several other important factors to determine the reclamation priority ranking.

TASK 10 - ESTABLISH PRIORITIES

Abatement area priority rankings can be formulated after careful assessment, consideration, and weighing of the following important factors:

- Location within watershed;
- Specific stream affected;
- Stream miles affected;
- Amount of pollution abated;
- Effects of abatement on receiving streams;
- Legal complications with property owners;
- Active mine permits;
- Potential land uses;
- Future mining potential;
- Economic need;
- Development demand;
- Public visibility;
- Ecology;
- Geology;
- Hydrology;
- Abatement or reclamation costs;
- Cost effectiveness; and
- Water related benefits derived from proposed reclamation and abatement.

Abatement projects can be listed either individually or in groups according to priority ranking as determined after consideration of all these factors. High priority projects will generally be those with either the best cost effectiveness or the greatest predicted downstream water quality improvement. These should be given primary consideration for immediate implementation, particularly where reclamation and abatement funding is limited.

TASK 11 - DEVELOP QUICK START PROJECTS

Early Action Projects are usually recognized during the course of a project such as this, and obviously satisfy most or all of the criteria used for establishing final priorities. Therefore, they can be implemented immediately with the assurance that they stand on their own merit economically, and with the further assurance that they will eventually wind up high on any list of priorities: Benefit/Cost Ratics, High Public Visibility, or immediate Need for Reclamation.

Should Quick Start Projects be implemented, there are a number of steps which must be taken:

1. The selected projects should be documented in detail.
2. Applications for Federal funding should be made.
3. Where possible, sufficiently detailed project cost estimates should be developed.
4. Specific problems related to reclamation should be identified.
5. Solutions should be proposed.
6. Recommendations should be documented.

Interim reports for each recommended Quick Start project should be submitted as the project formulates, for use by the appropriate department or agency in soliciting funds and initiating reclamation or abatement action.

TASK 12 - FINALIZE MAPPING

The sequence of mapping in various levels of study effort described in this report can, if properly developed and presented, accurately represent the various phases or level of effort involved in reducing the scope of study from statewide to local to specific mine site level. Properly selected mapping scales combined with logical mapping and presentation is vital at all levels of study. As the illustration in Figure 5-1 shows, the progression of studies and associated mapping actually proceeds in a series of stages from the initial statewide program to specific reclamation and abatement sites. Stage I on the illustration represents a final map derived from the statewide mined land inventory and reclamation priority planning program. A typical portion of a Stage I map, representing the visual output of a statewide study, is shown in Figure 5-2. Study findings and watershed conditions shown on this map represent the level of detail typically achieved in Stage I studies, i.e. sample locations, general areas of surface and underground mine concentrations, and gross water quality on a subwatershed basis. This level of study effort and mapping is the specific subject of this report, and the technical approaches to the study and development of such a map are detailed in Chapter 4 of this section.

Stage II in Figure 5-1 represents a typical watershed feasibility study that would be conducted in one of the high priority watersheds. Requirements and procedures for Stage II watershed studies are discussed in detail in this chapter. Final Stage II mapping would consist of two distinct maps or sets of maps which would represent both Stages II and III in Figure 5-1. At the Stage II level, a watershed feasibility evaluation would yield a summary or index map as illustrated for Watershed No. 29 in Figure 5-3. Such a map would focus on the study watershed, showing detailed water quality, specific locations and configurations of individual surface and underground mines, locations of point sources of pollution, and delineation of specific abatement areas. In general, this map will present water quality and mining conditions of the watershed in summary form for quick observation and, will serve as an index to the specific abatement or subwatershed areas established throughout the watershed study area.

The Stage III level of mapping, which would consist of specific subwatershed areas or proposed reclamation sites, would also be generated during the watershed feasibility study discussed in the section. Typical mine development drawings for individual underground and surface mine sites are shown in Figures 5-4, 5-5, and 5-6. As can be seen, these mine development drawings may be developed to illustrate single abatement sites, or a number of sites within a

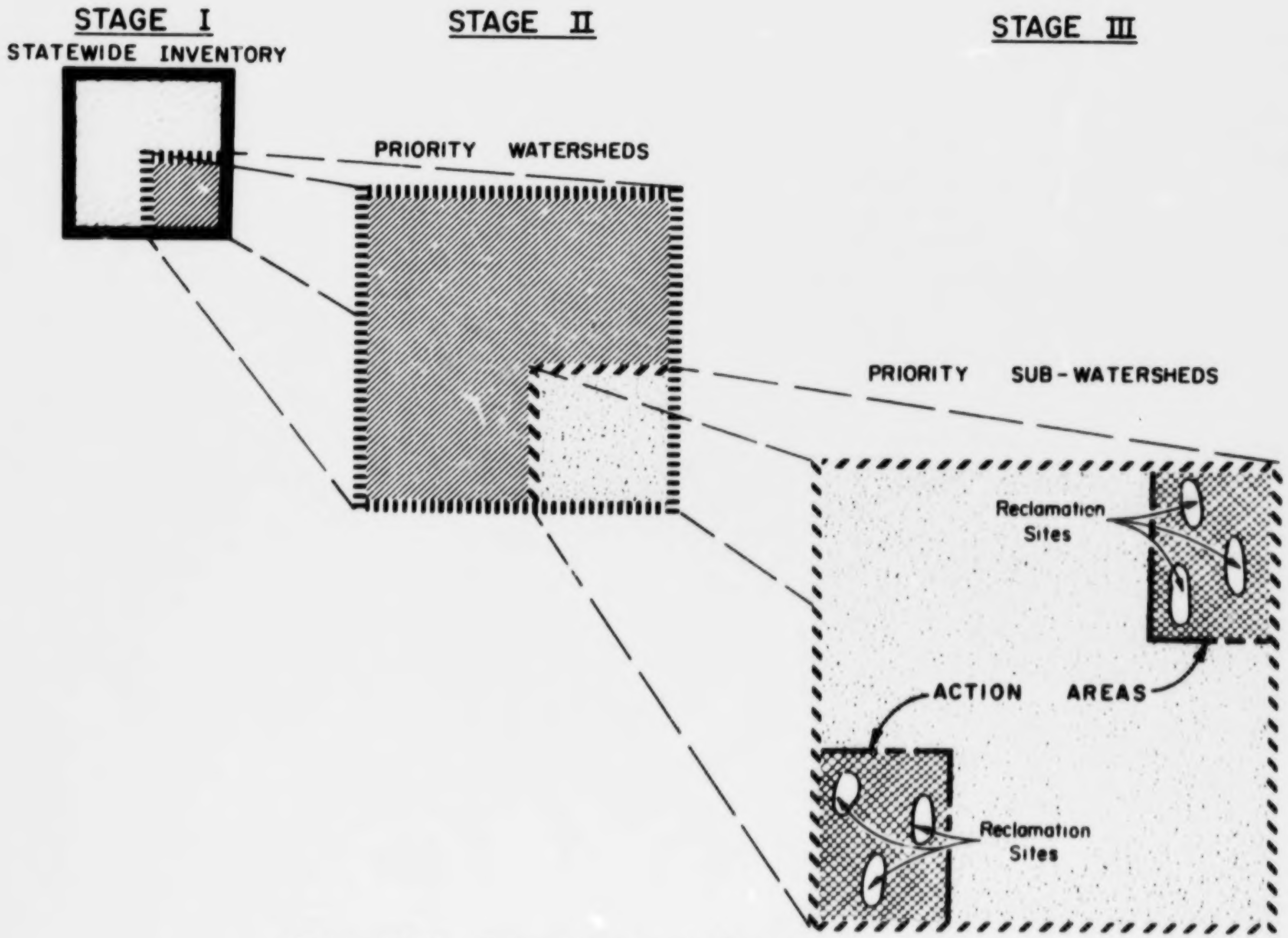

Figure 5-1. Successive resolution of study areas.

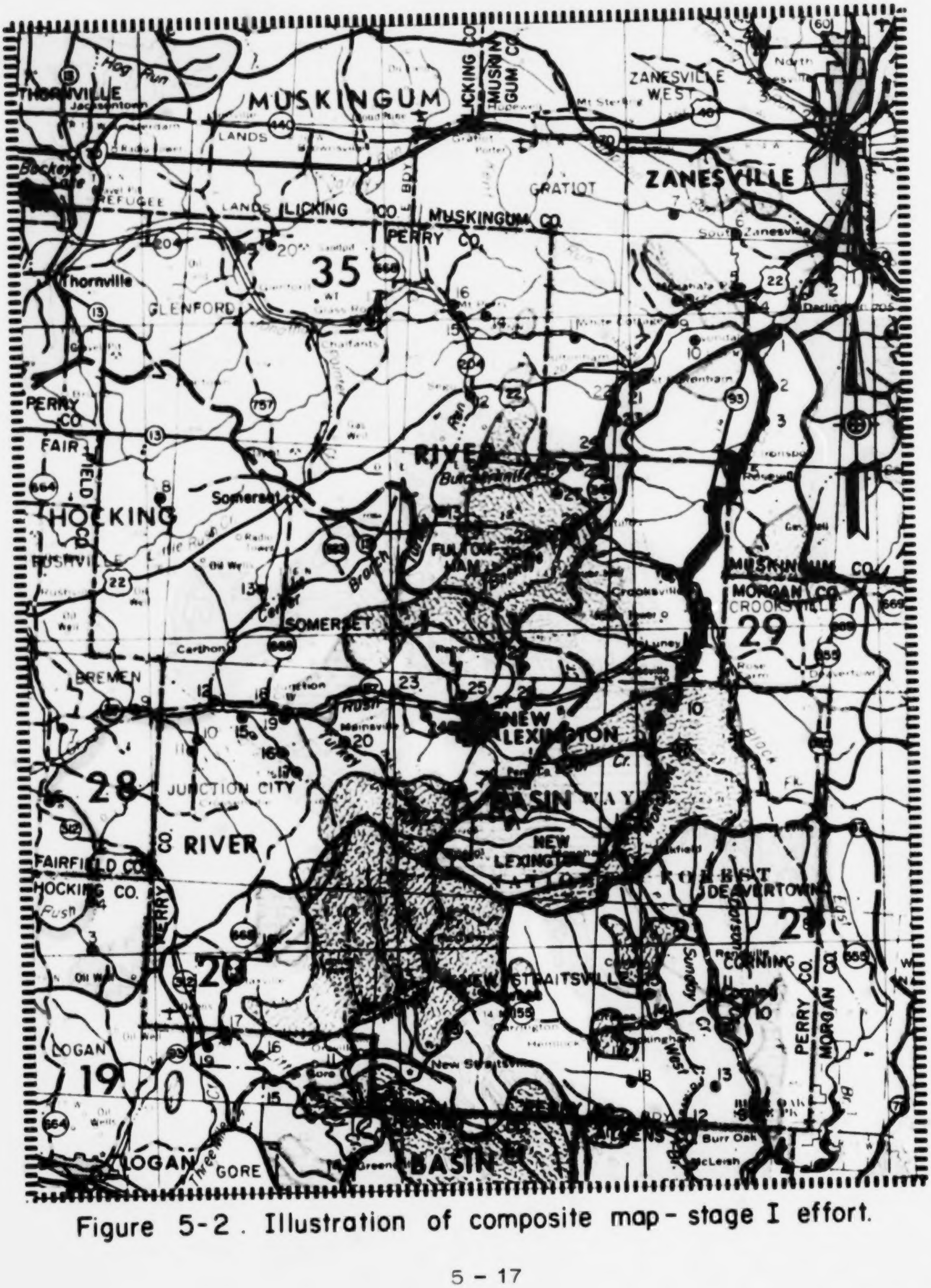

Figure 5-2. Illustration of composite map - stage I effort.

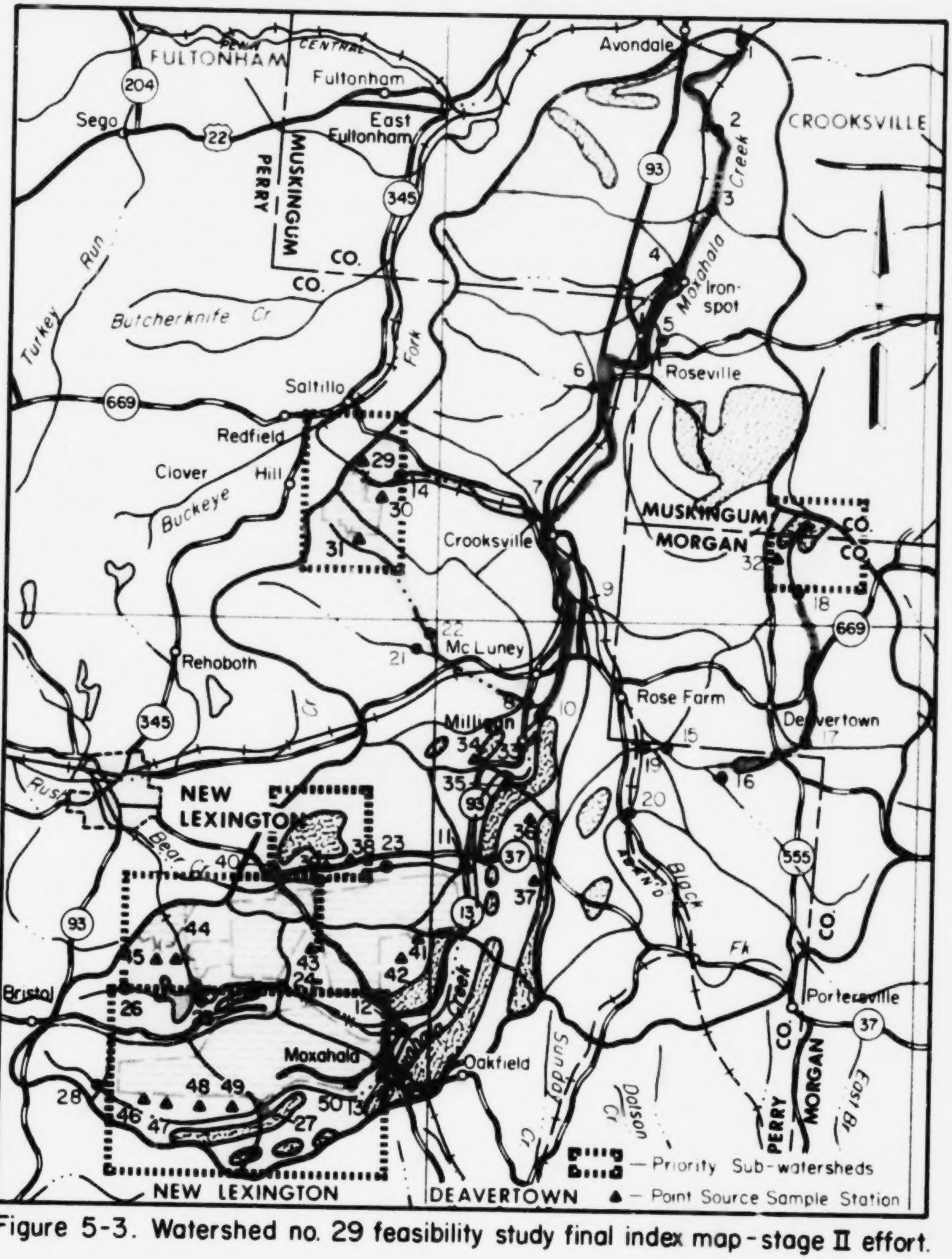

Figure 5-3. Watershed no. 29 feasibility study final index map - stage II effort.

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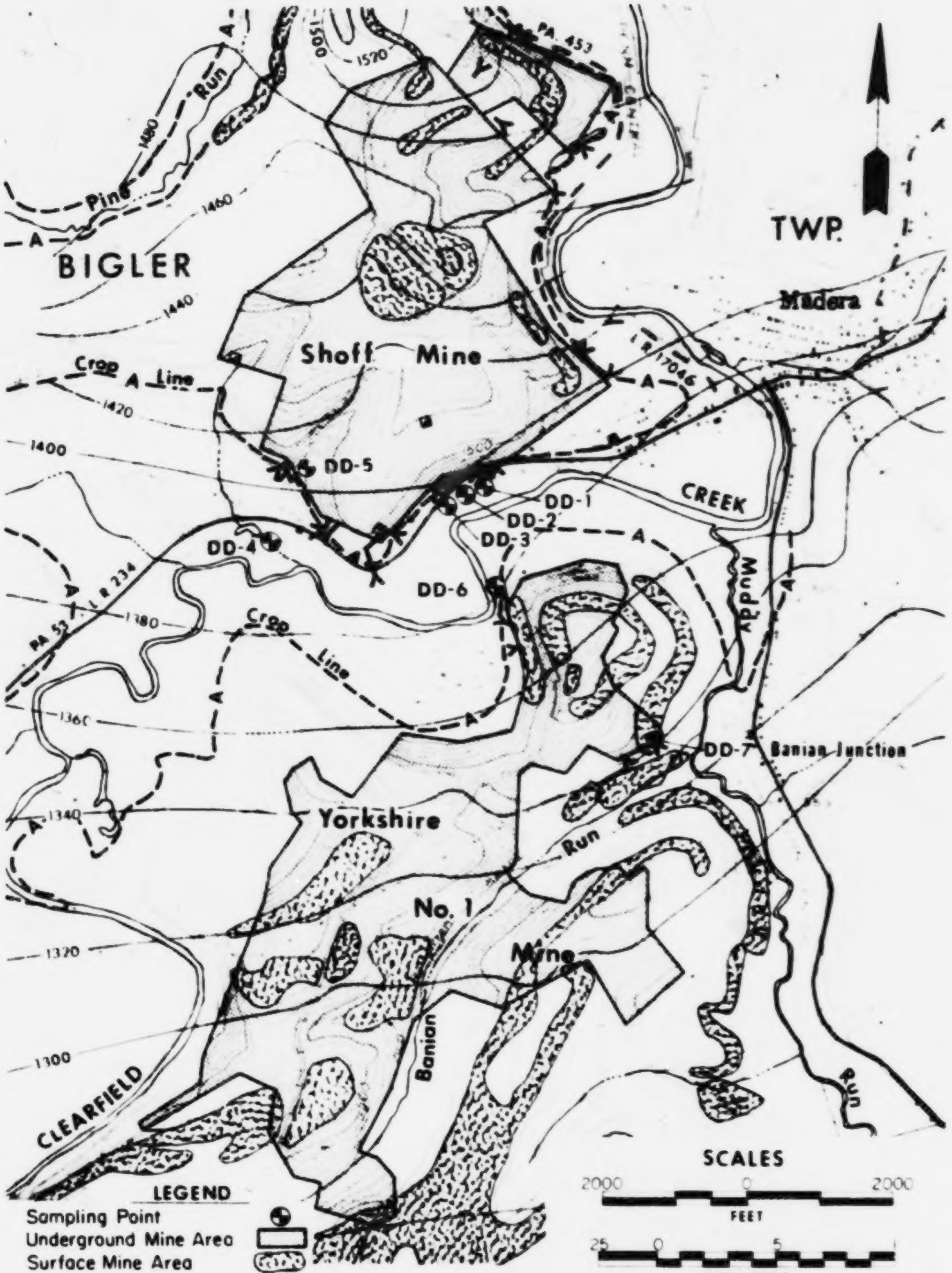

Figure 5-4 Watershed feasibility study abatement area location and geology map for underground mines—stage III effort.

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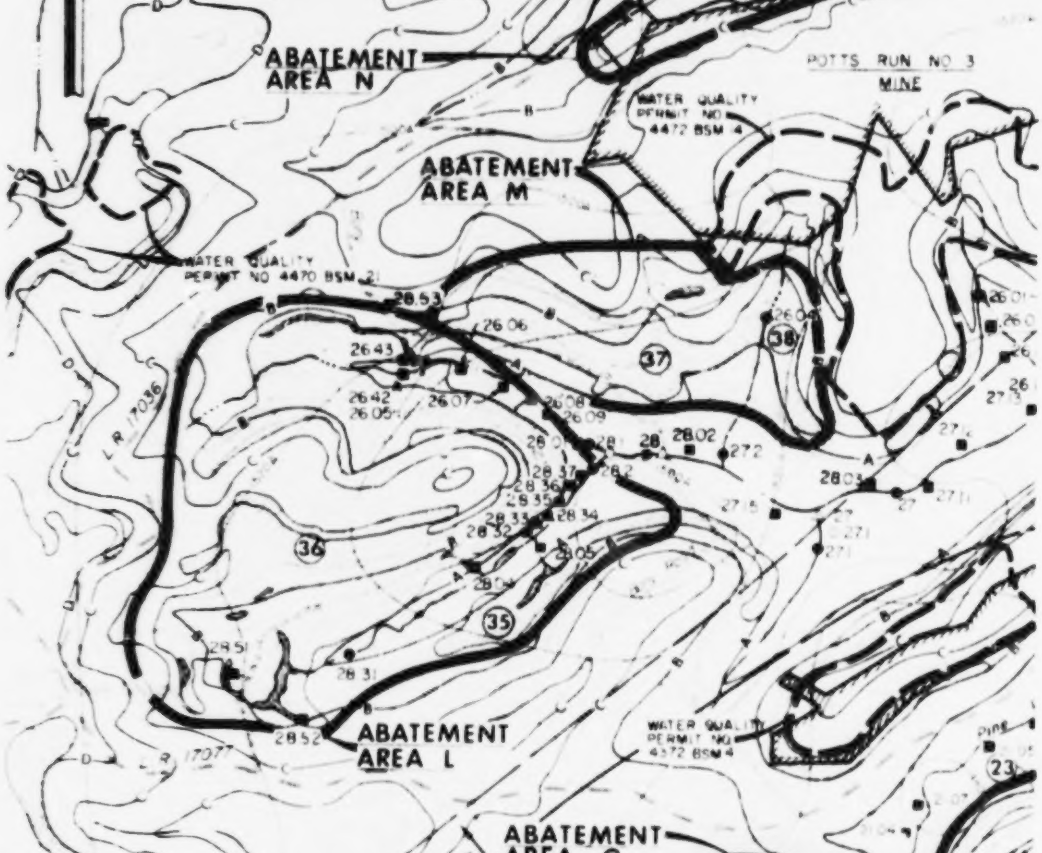

ABATEMENT AREA N
ABATEMENT AREA M
ABATEMENT AREA L
ABATEMENT AREA G
POTTS RUN NO. 3 MINE
WATER QUALITY PERMIT NO. 4472 BSM 4
WATER QUALITY PERMIT NO. 4470 BSM 21
WATER QUALITY PERMIT NO. 4372 BSM 4
WATER QUALITY PERMIT NO. 4470 BSM 20
WATER QUALITY PERMIT NO. 4370 BSM 15
L.R. 17036
L.R. 17077
KNOX TOWNSHIP
BIGLER TOWNSHIP
LAUREL HILL ANTICLINE
CORONA MINE
CORONA MINE
LIMIT OF PROPOSED INUNDATION
39
38
37
36
35
25
24
23
21

Figure 5-5 Watershed feasibility study abatement area mine development drawing for surface mines — stage III effort.

Figure 5-5
LEGEND

△	**E.P.A. Stream Sample Station**	░	**Surface Mine**
⊙	**E.P.A. Mine Discharge Point**	—1500—	**Coal Structure Contours, "A" Seam**
◑	**Monthly & Module Sample Station**	▬	**Limit of Abatement Area**
◖	**Module Sample Station**	▨	**Major Surface Mine Pool**
■	**Point Source Sample Station**	(24)	**Surface Mine Number**
≻	**Portal**	—A—	**Outcrop Line**
▪	**Mine Shaft**	▪ ▬ ▬	**Active Mining Permit Boundary**
		//////	**Underground Mine "A" Seam**

single geographic area. These illustrations are taken from completed watershed studies unrelated to the fictitious Watershed No. 29, and are included here merely as typical mine development drawings. Ideally, these maps should be on a fairly detailed scale such as 1 cm. = 240 m. (1 in. = 2000 ft.) USGS 7.5 minute topographic quadrangle scale or 1 cm. = 120 m. (1 in. = 1000 ft.) to permit the maximum amount of information to be presented. Data which should be plotted on mine development maps include:

- Surface and underground mine boundaries;
- Underground mine entries, air shafts, refuse disposal areas, discharge points;
- Structure contours on the mineral deposit;
- Stream and pollution point source sampling points;
- Abandoned refuse piles;
- Mineral preparation areas;
- Impoundments;
- Active mining permits;
- Public versus private land ownership.

Depending on the specific mineral mined and extractive techniques used within a watershed, it may be necessary or desirable to alter types of data included on a Mine Development Map. Completed mine development drawings should have all of the basic and background information necessary for initiation of engineering design work. Color usage can greatly enhance map readability but careful selection of symbols can also permit clear presentation of the same data in black and white (See sample figures).

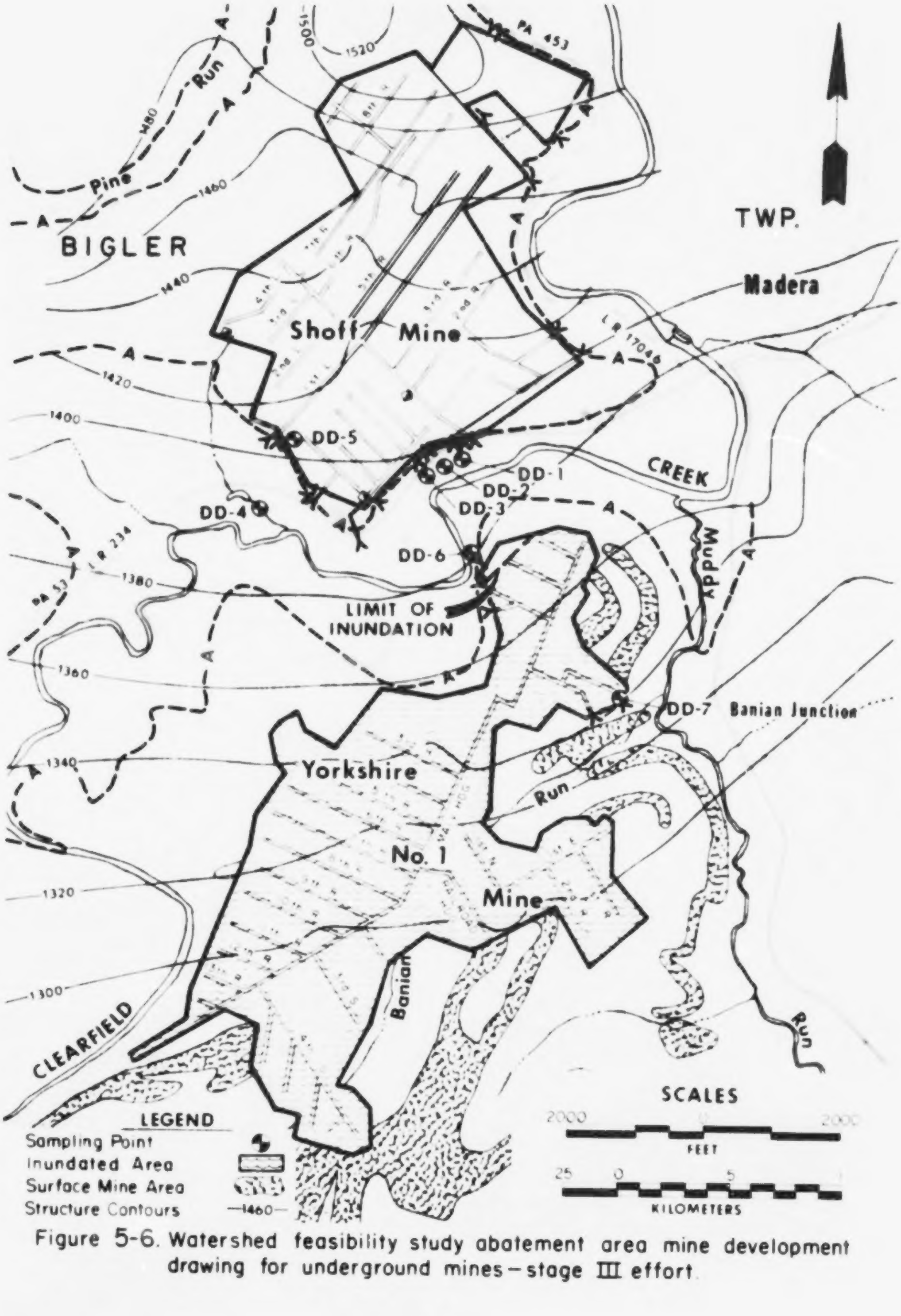

Figure 5-6. Watershed feasibility study abatement area mine development drawing for underground mines—stage III effort.

TASK 13 - PREPARE FINAL REPORT

The methods and results of feasibility evaluation should be incorporated into a final report. Data must be organized and presented in an easily readable and understandable fashion. Location maps, regional maps, mine development drawings for all abatement areas, graphs, charts and other appropriate visual aids should be included for ease in digesting narrative portions of the report. The report should include a narrative discussion of each abatement or reclamation area including justification and benefits derived from recommended procedures. All mapping completed during the feasibility study should be submitted separately, as background information for the final report. Reproducible originals of all mapping should be kept available for future reproduction if required. The report should:

- Describe tangible and intangible benefits of the recommended program.
- Develop scheduling and budgeting to assure adequate administrative control of the reclamation plan.
- Recommend facilities and a continuing program for surveillance of any mine drainage from the improved area.
- Delineate means for measuring the accomplishments of the program with respect to the objectives.

TASK 14 - POST RECLAMATION MONITORING AND ASSESSMENT

Post reclamation site monitoring and assessment is the final phase of the initial step towards reclaiming inactive or abandoned mined lands, and lasts from 1 to 5 years, during which reclamation results are evaluated. Monitoring surveys include reactivation of sampling stations established during the inventory survey, and installation of new stations as required to document post-abatement water quality. Sampling networks should be designed to accurately reflect effects on the subject streams and mine discharges.

Lengthy water quality surveillance is not always possible with today's high labor and materials costs. However, every effort should be made to compare conditions "before and after" reclamation, thus providing a feed-back system for overall program guidance and modification.

The state agency which conducted the initial water and land inventory should make an assessment of benefits attained to maintain a continuity of techniques, analyses, and evaluation procedures. A final project critique-type report should be developed to include both negative and positive findings, establish viable reclamation and pollution abatement alternatives, and justify future state pollution abatement and reclamation projects.

CHAPTER 6

SECONDARY USE OF LAND INVENTORY DATA

SECONDARY USE OF LAND INVENTORY DATA

Inherent to the planning and evaluation of a statewide abatement and reclamation program is the collection of tremendous amounts of qualitative and quantitative data. Depending upon the format and techniques utilized in the data collection, much of this information can be utilized by other state, federal, and county government and non-government groups and individuals. Not surprisingly, it can be the secondary user groups which play a major role in assisting a statewide abatement and reclamation program establishing its:

1. public visibility
2. credibility
3. viability

These three factors are important determinants to the continuation of a program.

Availability of massive amounts of usable data from one agency also serves to:

1. increase communication among existing and potential user groups;

2. help establish the lending agencies role and dominance;

3. reduce duplication of data collection and reduce program cost by maximizing utility of available information.

Included within this section are tables listing potential user groups - federal, state and county - for inventory data. The listings have been compiled based upon the authors' familiarity with the groups cited and should not be considered as all inclusive.

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Table 6-1
SECONDARY USES OF INVENTORY DATA

FEDERAL GOVERNMENT			Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Bureau	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Services Centers	Development Centers
Interior	Bureau of Sport Fisheries and Wildlife	Preserving and enhancing water and related resources for sport fishing	X	X			X	X	X		X		X	X	X		X	X	X			
		Research in waterfowl management, migratory bird routes, upland wildlife work	X	X		X	X	X	X	X	X	X	X				X	X				
		Fishery and wildlife management	X	X		X	X	X	X	X	X	X	X	X	X		X	X	X			X
		Evaluates proposed state and federal water use projects	X	X			X	X	X		X	X	X				X	X			X	X
		Development of comprehensive river basin plans with future recreation needs based on fish and wildlife	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	National Park Service	Interpretive, investigative, informational programs relating to park resources and use	X	X	X	X	X	X	X	X	X	X	X									

Table 6-1 Continued
SECONDARY USES OF INVENTORY DATA

FEDERAL GOVERNMENT			Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Bureau	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Interior	Bureau of Mines	Surveillance, evaluation of industrial and commercial outlook for minerals, fuel deposits	X		X							X					X	X				
		Studies relationships of mineral industries to environmental problems	X	X	X	X	X	X	X		X	X	X	X	X		X				X	
		Engineering studies regarding effective mining practices, increased mineral production	X		X		X	X	X	X	X	X										
		Research programs on extraction, uses and disposal of minerals and mineral fuel	X	X	X	X	X	X	X			X	X	X	X		X	X		X	X	X
	Geological Survey	Classify Federal lands values for leasable minerals, reservoir and waterpower sites.	X	X	X		X	X	X	X	X	X	X				X	X		X	X	X

Table 6-1 Continued
SECONDARY USES OF INVENTORY DATA

FEDERAL GOVERNMENT			Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Bureau	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Interior	Geological Survey	Evaluate and limit damage or pollution to the total environment	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X				
		Prepare maps, report of mineral and water resources on Federal lands	X	X	X	X	X	X	X								X					
		Geologic surveys to determine and appraise mineral and mineral fuel resources and geologic structure	X		X					X	X	X										
		Administer and assist in exploration program for discovery of domestic mineral reserves by private industry	X		X							X										

Table 6-1 Continued
SECONDARY USES OF INVENTORY DATA

FEDERAL GOVERNMENT			Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Bureau	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Interior	Bureau of Outdoor Recreation	Prepare and maintain inventory and evaluation of U. S. Outdoor Recreation Resources; and develop nationwide recreation plan	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Bureau of Reclamation	Allocate water resources on arid lands in western state	X	X	X	X	X	X	X	X	X	X	X				X	X			X	X
	Bureau of Land Management	Manage public lands and their resources	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X				
		Responsible for mineral leasing on public lands	X	X	X	X	X	X	X	X	X	X	X				X					
		Develop recreational opportunities on public lands	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Bureau of Indian Affairs	Utilize natural resources for economic and social development of Indian people	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 6-1 Continued
SECONDARY USES OF INVENTORY DATA

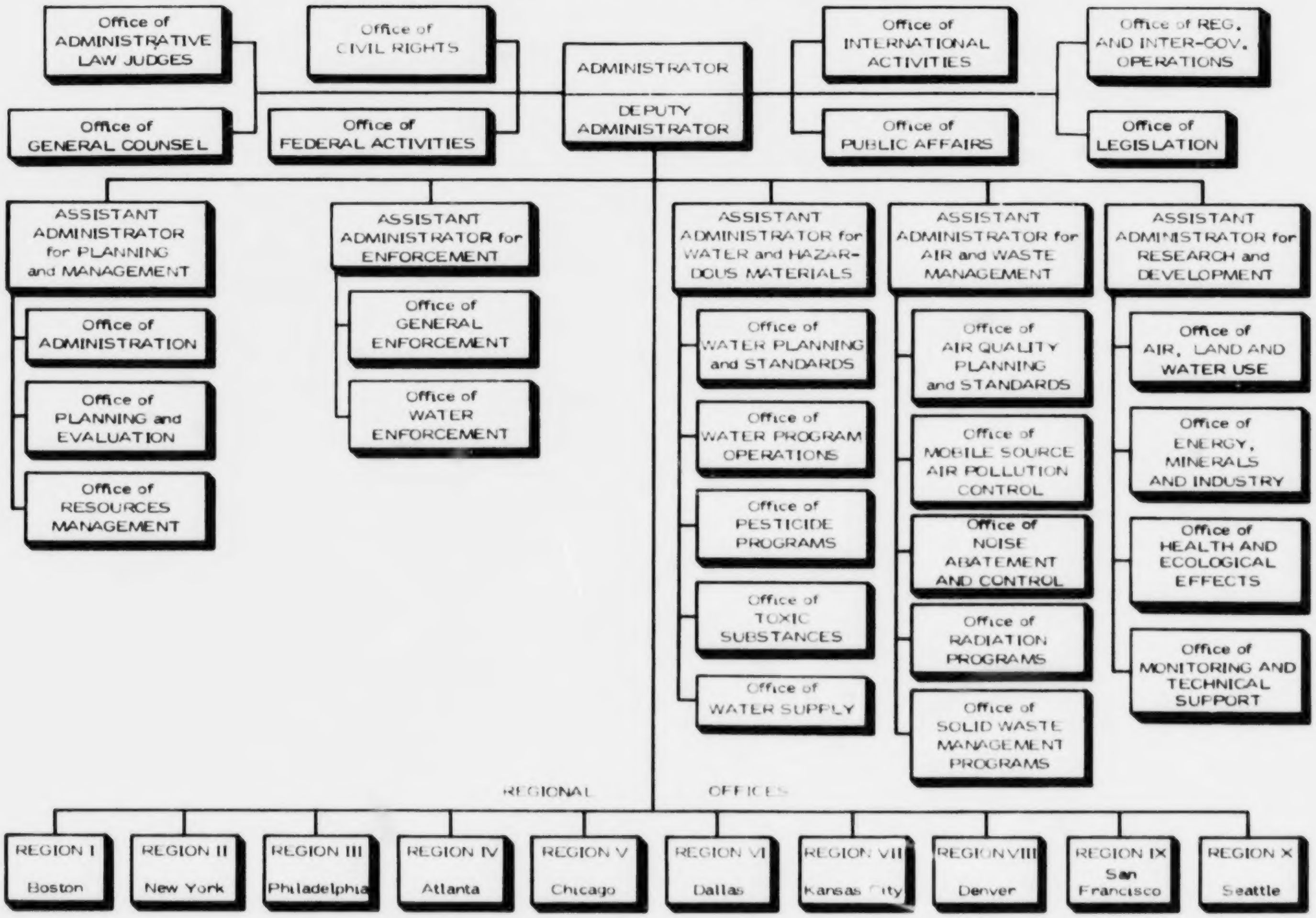
FEDERAL GOVERNMENT			Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Bureau	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Interior	Bureau of Indian Affairs	Administers cooperative services for leasing of mineral deposits	X	X	X	X											X			X		
	Office of Energy and Minerals	Develops emergency energy plans	X		X									X	X		X	X				
		Administers plans and programs for adequate maintenance of fuels and minerals	X		X									X	X							
Agriculture	Forest Service	Administers, manages and protects national forests	X	X	X	X	X	X	X	X	X	X	X				X			X		
	Soil Conservation Service	Administers national soil and water conservation program — including soil erosion control, flood prevention, soil mapping	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 6-1 Continued
SECONDARY USES OF INVENTORY DATA

FEDERAL GOVERNMENT			Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Bureau	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Agriculture	Agricultural Extension Service	Provides free consulting services to citizens in solving household and environmental problems	X	X		X	X	X	X	X	X	X	X				X				X	
Environmental Protection Agency	Mining & Spills Control	Seeks to prevent as well as remedy environmental impact of coal mining. Also performs studies to prevent oil spills	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

Table 6-2

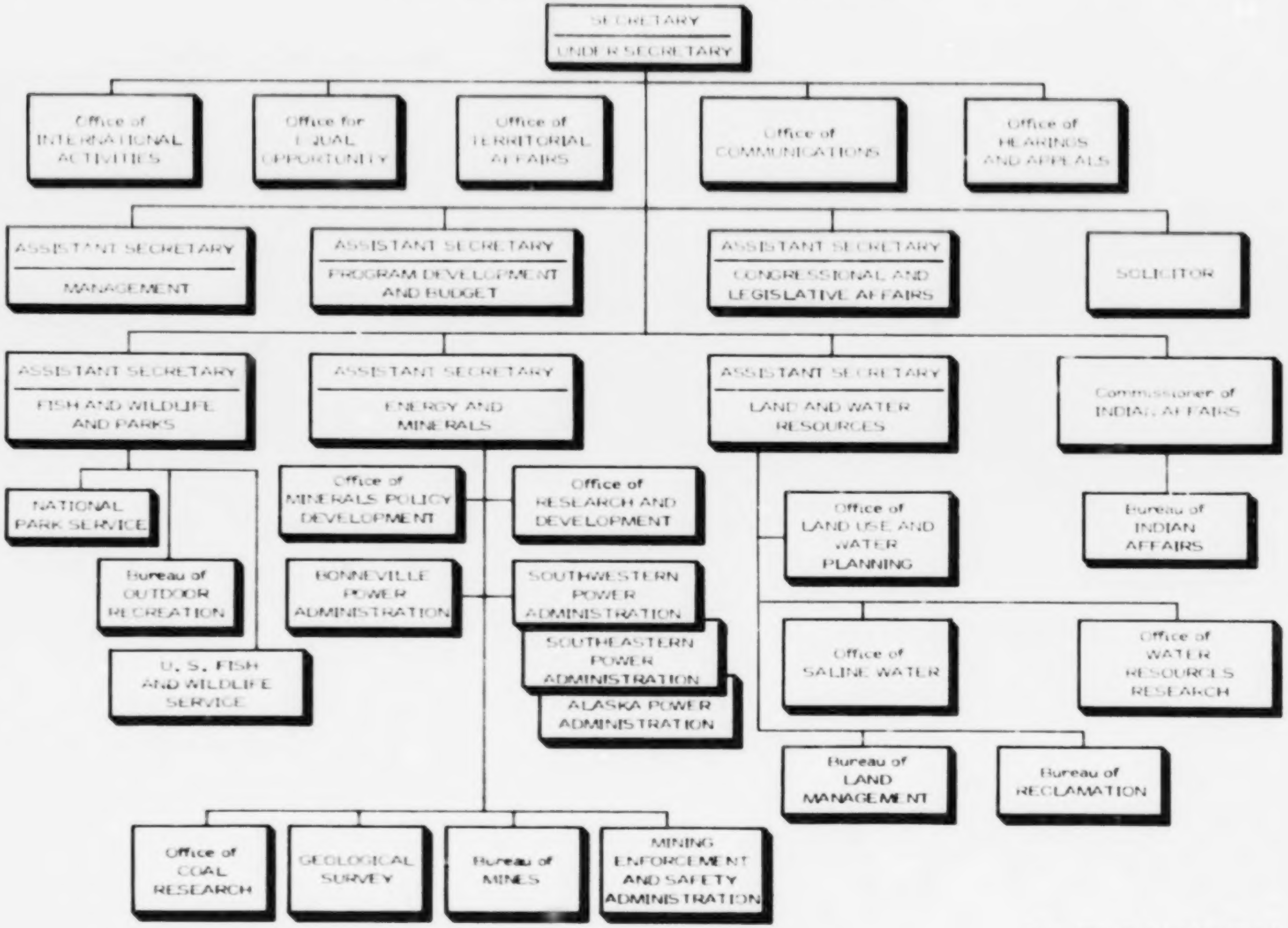
U.S. ENVIRONMENTAL PROTECTION AGENCY


Office of ADMINISTRATIVE LAW JUDGES
Office of GENERAL COUNSEL
Office of CIVIL RIGHTS
Office of FEDERAL ACTIVITIES
ADMINISTRATOR
DEPUTY ADMINISTRATOR
Office of INTERNATIONAL ACTIVITIES
Office of PUBLIC AFFAIRS
Office of REG. AND INTER-GOV. OPERATIONS
Office of LEGISLATION
ASSISTANT ADMINISTRATOR for PLANNING and MANAGEMENT
Office of ADMINISTRATION
Office of PLANNING and EVALUATION
Office of RESOURCES MANAGEMENT
ASSISTANT ADMINISTRATOR for ENFORCEMENT
Office of GENERAL ENFORCEMENT
Office of WATER ENFORCEMENT
ASSISTANT ADMINISTRATOR for WATER and HAZARDOUS MATERIALS
Office of WATER PLANNING and STANDARDS
Office of WATER PROGRAM OPERATIONS
Office of PESTICIDE PROGRAMS
Office of TOXIC SUBSTANCES
Office of WATER SUPPLY
ASSISTANT ADMINISTRATOR for AIR and WASTE MANAGEMENT
Office of AIR QUALITY PLANNING and STANDARDS
Office of MOBILE SOURCE AIR POLLUTION CONTROL
Office of NOISE ABATEMENT AND CONTROL
Office of RADIATION PROGRAMS
Office of SOLID WASTE MANAGEMENT PROGRAMS
ASSISTANT ADMINISTRATOR for RESEARCH and DEVELOPMENT
Office of AIR, LAND AND WATER USE
Office of ENERGY, MINERALS AND INDUSTRY
Office of HEALTH AND ECOLOGICAL EFFECTS
Office of MONITORING AND TECHNICAL SUPPORT
REGIONAL OFFICES
REGION I Boston
REGION II New York
REGION III Philadelphia
REGION IV Atlanta
REGION V Chicago
REGION VI Dallas
REGION VII Kansas City
REGION VIII Denver
REGION IX San Francisco
REGION X Seattle

From "The Federal Directory"
June 5, 1975

Table 6-4

DEPARTMENT OF THE INTERIOR


SECRETARY
UNDER SECRETARY
Office of INTERNATIONAL ACTIVITIES
Office for EQUAL OPPORTUNITY
Office of TERRITORIAL AFFAIRS
Office of COMMUNICATIONS
Office of HEARINGS AND APPEALS
ASSISTANT SECRETARY
MANAGEMENT
ASSISTANT SECRETARY
PROGRAM DEVELOPMENT AND BUDGET
ASSISTANT SECRETARY
CONGRESSIONAL AND LEGISLATIVE AFFAIRS
SOLICITOR
ASSISTANT SECRETARY
FISH AND WILDLIFE AND PARKS
ASSISTANT SECRETARY
ENERGY AND MINERALS
ASSISTANT SECRETARY
LAND AND WATER RESOURCES
Commissioner of INDIAN AFFAIRS
NATIONAL PARK SERVICE
Bureau of OUTDOOR RECREATION
U. S. FISH AND WILDLIFE SERVICE
Office of MINERALS POLICY DEVELOPMENT
Office of RESEARCH AND DEVELOPMENT
BONNEVILLE POWER ADMINISTRATION
SOUTHWESTERN POWER ADMINISTRATION
SOUTHEASTERN POWER ADMINISTRATION
ALASKA POWER ADMINISTRATION
Office of LAND USE AND WATER PLANNING
Bureau of INDIAN AFFAIRS
Office of SALINE WATER
Office of WATER RESOURCES RESEARCH
Bureau of LAND MANAGEMENT
Bureau of RECLAMATION
Office of COAL RESEARCH
GEOLOGICAL SURVEY
Bureau of MINES
MINING ENFORCEMENT AND SAFETY ADMINISTRATION

From "The Federal Directory"
3rd Edition 1975

Table 6-4
SECONDARY USES OF INVENTORY DATA

STATE GOVERNMENT		Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Economic Development	City/regional planning, zoning	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Identification of development pressures and patterns - industrial, commercial, residential	X	X	X	X										X	X	X	X	X	X	X
Agriculture	Land use studies	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Crop production potentials	X			X				X	X	X					X					
	Evaluate channelization, siltation erosion, livestock waste impacts	X	X		X	X	X	X	X	X	X		X	X		X					
Environmental Protection	Evaluation and regulation of sanitary landfills, industrial effluents, air pollution sources, air and water abatement projects, waste water treatment plants, water monitoring stations, engineering projects	X	X			X	X	X	X	X	X	X	X	X		X	X			X	X
Public Utilities Commission	Evaluation of electric, gas, telephone, water, railroad rights of way	X							X	X	X					X	X	X	X	X	X
Commerce	Evaluating real estate development and public lands	X	X						X	X	X				X	X	X	X	X	X	X
Taxation	Assess and collection state tax revenues	X														X	X	X	X	X	X
Public Works	Maintenance and care of state owned buildings and properties, particularly state institutions	X																			

Table 6-4 Continued
SECONDARY USES OF INVENTORY DATA

STATE GOVERNMENT		Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Welfare	Providing services to low-income disabled, unemployed, handicapped	X														X	X	X	X	X	X
Natural Resources	Forestry management	X	X		X				X	X	X	X	X	X			X		X		
	Land use planning	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Parks and recreation planning, expansion, improvements, protection, management	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Wildlife management, preserve establishment	X	X	X	X	X	X	X			X	X				X	X			X	X
	Mineral reserve evaluation, exploration	X		X							X					X	X	X		X	X
	Hydrologic and geologic evaluations	X	X	X		X	X	X	X	X	X										
	Oil and gas drilling, monitoring	X	X	X		X	X	X	X	X	X		X	X							
	Water resource management	X	X			X	X	X	X	X	X	X	X	X		X	X	X	X	X	X
	Water quality monitoring	X	X			X	X	X		X			X	X		X	X			X	X
	Soils classification base mapping	X							X	X	X					X					
	Land use evaluations	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Long range drainage planning																				
Transportation	Highway engineering	X							X	X	X										
	Highway assessment, expansion, improvement	X							X	X	X	X				X	X	X	X	X	X
	Transportation pattern evaluation, long range planning	X														X	X	X		X	X

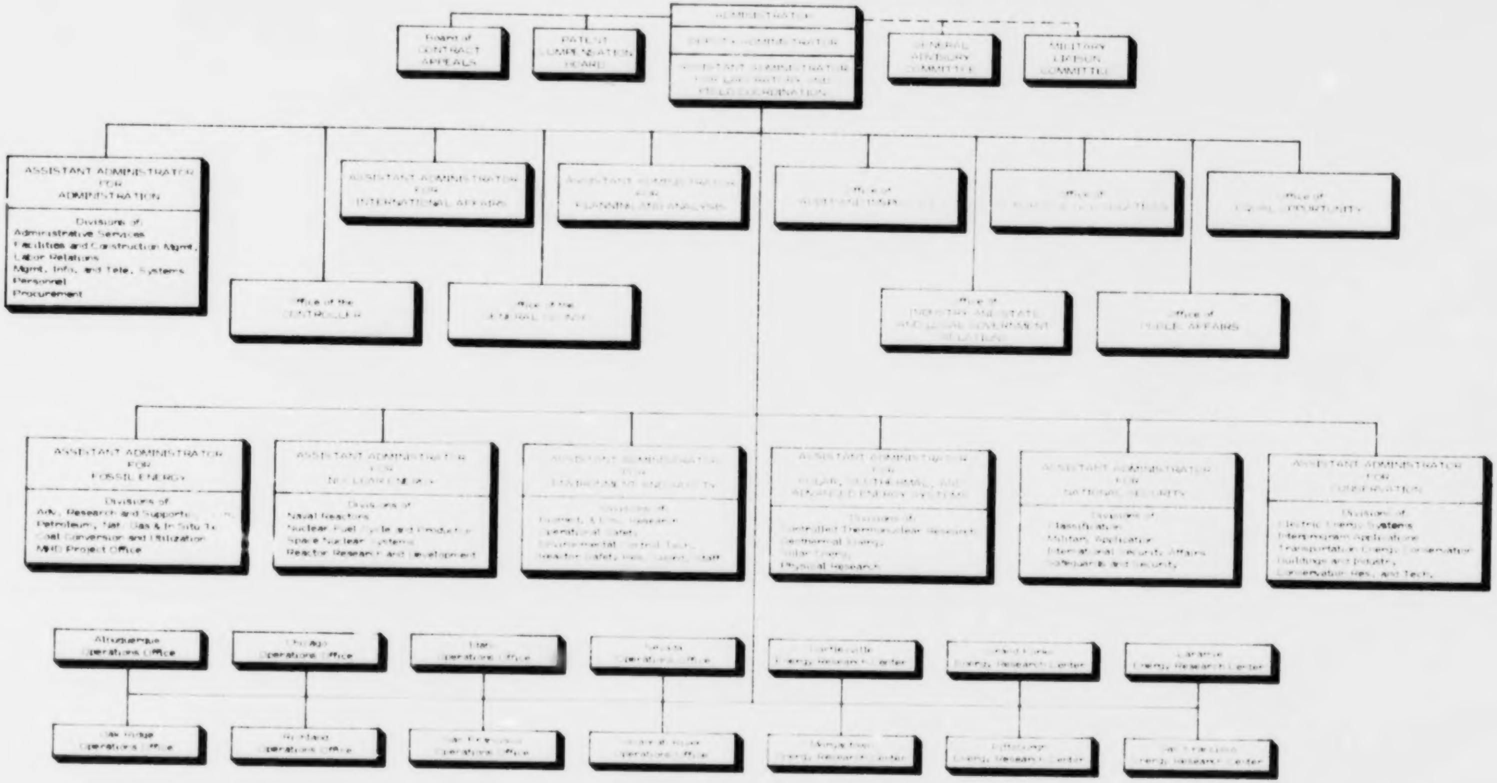
Table 6-4 Continued

SECONDARY USES OF INVENTORY DATA

STATE GOVERNMENT		Mapping				Water Quality			Terr. Quality				Visual Quality			Socio-Economic Character					
Department	Function	Base	Stream	Mineral	Vegetative	Biological	Chemical	Physical	Soils	Drainage	Terrain	Wildlife	Wastes	Refuse	Buildings	Land Use	Demographic	Roads	Land Value	Service Centers	Development Centers
Health	Protects health and safety of state residents	X	X			X	X	X					X	X	X	X	X			X	X
Education	Directs, Administers and Controls Quality of public education systems	X															X	X		X	X
COUNTY GOVERNMENT																					
County Commissioners	Electorate body governing all county offcers. Establish county programs and policies	X														X	X	X	X	X	X
County Engineers	Provide County engineering services. Supervises county construction projects and roads	X	X						X	X	X					X	X	X	X	X	X
County Health	Provides County health services. Monitors local water supplies and food services	X	X			X	X	X									X			X	X
Taxation	Assess and collection of county taxes	X														X	X		X	X	X
Planning Commission	Responsible for planning and developing community resources	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

TABLE 6-5

ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION


Board of CONTRACT APPEALS
PATENT COMPENSATION BOARD
ADMINISTRATOR
DEPUTY ADMINISTRATOR
ASSISTANT ADMINISTRATOR FOR LABORATORY AND FIELD COORDINATION
GENERAL ADVISORY COMMITTEE
MILITARY LIAISON COMMITTEE
ASSISTANT ADMINISTRATOR FOR ADMINISTRATION
Divisions of:
Administrative Services
Facilities and Construction Mgmt.
Labor Relations
Mgmt. Info. and Tele. Systems
Personnel
Procurement
ASSISTANT ADMINISTRATOR FOR INTERNATIONAL AFFAIRS
ASSISTANT ADMINISTRATOR FOR PLANNING AND ANALYSIS
Office of
Office of
Office of EQUAL OPPORTUNITY
Office of the CONTROLLER
Office of the GENERAL COUNSEL
Office of INDUSTRY AND STATE AND LOCAL GOVERNMENT RELATIONS
Office of PUBLIC AFFAIRS
ASSISTANT ADMINISTRATOR FOR FOSSIL ENERGY
Divisions of
Adv. Research and Supporting
Petroleum, Nat. Gas & In Situ Tx
Coal Conversion and Utilization
MHD Project Office
ASSISTANT ADMINISTRATOR FOR NUCLEAR ENERGY
Divisions of
Naval Reactors
Nuclear Fuel Cycle and Production
Space Nuclear Systems
Reactor Research and Development
ASSISTANT ADMINISTRATOR FOR ENVIRONMENT AND SAFETY
Divisions of
Biomed. & Env. Research
Operational Safety
Environmental Control Tech.
Reactor Safety Res. Coord. Staff
ASSISTANT ADMINISTRATOR FOR SOLAR, GEOTHERMAL, AND ADVANCED ENERGY SYSTEMS
Divisions of
Controlled Thermonuclear Research
Geothermal Energy
Solar Energy
Physical Research
ASSISTANT ADMINISTRATOR FOR NATIONAL SECURITY
Divisions of
Classification
Military Application
International Security Affairs
Safeguards and Security
ASSISTANT ADMINISTRATOR FOR CONSERVATION
Divisions of
Electric Energy Systems
Interprogram Applications
Transportation Energy Conservation
Buildings and Industry
Conservation Res. and Tech.
Albuquerque Operations Office
Chicago Operations Office
Idaho Operations Office
Nevada Operations Office
Bartlesville Energy Research Center
Grand Forks Energy Research Center
Laramie Energy Research Center
Oak Ridge Operations Office
Richland Operations Office
San Francisco Operations Office
Savannah River Operations Office
Morgantown Energy Research Center
Pittsburgh Energy Research Center
San Francisco Energy Research Center

From: Environmental Protection Agency

Table 6-6

Conversion Table

MULTIPLY (ENGLISH UNITS)		by		TO OBTAIN (METRIC UNITS)
English Unit	Abbreviation	Conversion	Abbreviation	Metric Unit
acre	ac	0.405	ha	hectares
acre - feet	ac ft	1233.5	cu m	cubic meters
British Thermal Unit	BTU	0.252	kg cal	kilogram - calories
British Thermal Unit/pound	BTU/lb	0.555	kg cal/kg	kilogram calories/kilogram
cubic feet/minute	cfm	0.028	cu m/min	cubic meters/minute
cubic feet/second	cfs	1.7	cu m/min	cubic meters/minute
cubic feet	cu ft	0.028	cu m	cubic meters
cubic feet	cu ft	28.32	l	liters
cubic inches	cu in	16.39	cu cm	cubic centimeters
degree Fahrenheit	°F	0.555(°F-32)*	°C	degree Centigrade
feet	ft	0.3048	m	meters
gallon	gal	3.785	l	liters
gallon/minute	gpm	0.0631	l/sec	liters/second
horsepower	hp	0.7457	kw	kilowatts
inches	in	2.54	cm	centimeters
inches of mercury	in Hg	0.03342	atm	atmospheres
pounds	lb	0.454	kg	kilograms
million gallons/day	mgd	3785	cu m/day	cubic meters/day
mile	mi	1.609	km	kilometer
pound/square inch (gauge)	psig	(0.06805 psig+1)*	atm	atmospheres (absolute)
square feet	sq ft	0.0929	sq m	square meters
square inches	sq in	6.452	sq cm	square centimeters
tons (short)	ton	0.907	kkg	metric tons (1000 kilograms)
yard	yd	0.9144	m	meters

* Actual conversion, not a multiplier

APPENDIX A

MINING SUPPORT INFORMATION

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Table A-1
MINING METHODS, BY MINERAL

MINERALS			TYPE OF MINING METHODS	USAGE	SECONDARY RECOVERY MINERALS
METALS	ALUMINUM	S U	Open Pit Room and Pillar	90% 10%	
	COPPER	S U	Open Pit, Solution Caving, Supported Stoping	33% 17%	Gold, Silver, Molybdenum, Iron, Lead, Zinc, Sulfur
	GOLD	S U	Open Pit, Hydraulic, Dredging Stoping Methods		Silver
	IRON ORE	S U	Open Pit, Area Room and Pillar	> 90% < 10%	Gold, Silver Sulfur, Copper, Phosphate
	LEAD	S U	Open Pit Room and Pillar, Block Caving, Shrinkage and Cut-and-Fill Stoping	< 50% > 50%	Copper, Gold Zinc, Silver, Sulfur
	MANGANESE	S U	Open Pit Room and Pillar, Longwall, Stoping Methods	> 50% < 50%	Lead, Zinc, Gold Copper, Silver
	MERCURY	S U	Open Pit Square Set, Shrinkage and Sublevel Stoping	< 50% > 50%	Stone
	MOLYBDENUM	S U	Open Pit Block Caving	50% 50%	Iron Sulfur, Tungsten
	SILVER	S U	Open Pit Horizontal Slice Cut, Hydraulic Fill Stoping	50% 50%	Copper, Lead and Zinc

Adapted from Reference No. 76

Table A-1 Continued

MINERALS			TYPE OF MINING METHODS	USAGE	SECONDARY RECOVERY MINERALS
METALS	TITANIUM	S	Open Pit, Dredging	> 50%	
		U	General Methods	< 50%	
	TUNGSTEN	S	Open Pit	< 50%	Copper, Gold Silver, Molybdenum
		U	Stoping Method	> 50%	
	URANIUM	S	Open Pit	50%	Copper, Silver Lead, Molybdenum
		U	Room and Pillar, Longwall Retreat, Panel Method	50%	
	ZINC	S	Open Pit	< 50%	Sulfur
		U	Open Shrinkage, Cut-and-Fill, Square Set Stoping	> 50%	
NON METALS	BARITE	S	Open Pit	> 50%	
		U	General Methods	< 50%	
	BORATE	S	Open Pit	100%	Potassium
	CLAY	S	Open Pit, Area, Hydraulic	> 50%	Mica, Stone Aluminum
		U	Room and Pillar	< 50%	
	DIATOMITE	S	Open Pit	100%	
	FELDSPAR	S	Open Pit	100%	Mica, Sand and Gravel
	GYPSUM	S	Open Pit	75%	
		U	Room and Pillar, Shrinkage and Open Stoping	25%	
	MAGNESITE AND BRUCITE	S	Open Pit	> 50%	
		U	Room and Pillar, Stoping Methods	< 50%	

Adapted from Reference No. 76

Table A-1 Continued

MINERALS		TYPE OF MINING METHODS		USAGE	SECONDARY RECOVERY MINERALS
NON METALS	MICA	S	Open Pit, Quarry	< 50%	
		U	General Methods	> 50%	
	PHOSPHATE ROCK	S	Open Pit, Area, Contour	> 50%	
		U	Top Slicing, and Open Stoping	< 50%	
	POTASH	S	Solution Mining	< 5%	Magnesium Salt
		U	Room and Pillar, Pillar-Robbing	> 95%	
	SALT	S	Solar Evaporation Solution	< 50%	
		U	Room and Pillar	> 50%	Magnesium Compounds
	SAND & GRAVEL	S	Open Pit, Dredging	100%	Gold, Silver
	STONE	S	Quarry	95%	Feldspar and Clay
		U	General Methods	95%	
	SULFUR	S	Open Pit	> 90%	
		U	Frasch	< 10%	

Adapted from Reference No. 76

Table A-1 Continued

MINERALS		TYPE OF MINING METHODS		USAGE	SECONDARY RECOVERY MINERALS
FOSSIL FUELS	COAL: BITUMINOUS LIGNITE	S	Area, Conventional Contour, Auger, Haulback, Mountain Top Removal, Multiseam, Modified Block Cut, Modified Area, Box Cut, Open Pit, Block Area	49%	
		U	Room and Pillar, Longwall, Shortwall	51%	
	COAL: ANTHRACITE	S	Open Pit, Conventional Strip	85%	
		U	Room and Pillar, Breast and Pillar, Slant Chute	15%	
	PEAT	S	Open Pit, Dredging, Hydraulic	100%	
	SHALE OIL	S	Open Pit	< 50%	Sulfur
		U	Room and Pillar, In Situ Retorting	> 50%	

Adapted from Reference No. 76

> - MORE THAN
< - LESS THAN
U - UNDERGROUND
S - SURFACE

Table A-2

MINERAL VALUES BY STATE

STATE	1972 TOTAL VALUE[1]	RANK	AREA (sq. mi.)	PER SQUARE MILE		1970 POPULATION[1]	PER CAPITA	
				VALUE	RANK		VALUE	RANK
ALABAMA	$ 371,241	21	51,609	$ 7,193	20	3,444	$ 108	20
ALASKA	286,138	25	586,412	488	50	300	954	4
ARIZONA	1,091,004	8	113,909	9,578	14	1,771	616	7
ARKANSAS	241,179	29	53,104	4,542	29	1,923	125	18
CALIFORNIA	1,851,365	3	158,693	11,666	12	19,953	93	25
COLORADO	425,841	19	104,247	4,085	32	2,207	193	14
CONN.	33,123	45	5,009	6,613	23	3,032	11	47
DELAWARE	2,871	50	2,057	1,396	42	548	5	49
FLORIDA	424,287	20	58,560	7,245	19	6,789	62	31
GEORGIA	258,041	28	58,876	4,383	30	4,590	56	33
HAWAII	28,074	46	6,450	4,353	31	769	37	37
IDAHO	106,206	36	83,557	1,271	44	713	149	17
ILLINOIS	769,737	10	56,400	13,648	9	11,114	69	28
INDIANA	322,608	22	36,291	8,889	16	5,194	62	32
IOWA	134,496	31	56,290	2,389	36	2,824	48	35
KANSAS	584,537	15	82,264	7,106	21	2,247	260	13
KENTUCKY	976,910	9	40,395	24,184	5	3,219	303	12
LOUISIANA	5,411,543	2	48,523	111,525	1	3,641	1,486	2
MAINE	22,922	47	33,215	690	49	992	23	41
MARYLAND	115,501	33	10,577	10,920	13	3,922	29	40
MASS.	52,428	43	8,257	6,350	27	5,689	9	48
MICHIGAN	694,767	13	58,216	11,934	11	8,875	78	27
MINNESOTA	659,669	14	84,068	7,647	17	3,805	173	15
MISS.	260,681	27	47,716	5,463	28	2,217	118	19
MISSOURI	451,817	16	69,686	6,484	24	4,677	97	24
MONTANA	307,676	24	147,138	2,091	38	694	443	10
NEBRASKA	73,675	41	77,227	954	46	1,483	50	34
NEVADA	181,702	30	110,540	1,644	39	489	372	11
N. HAMPSHIRE	10,111	48	9,304	1,087	45	738	14	46
N. JERSEY	113,760	34	7,836	14,518	8	7,168	16	45
N. MEXICO	1,097,292	7	121,666	9,019	15	1,016	1,080	3

Adapted From Reference No. 78

Table A-2 Continued

STATE	1972 TOTAL VALUE[1]	RANK	AREA (sq. mi.)	PER SQUARE MILE		1970 POPULATION[1]	PER CAPITA	
				VALUE	RANK		VALUE	RANK
N. YORK	$ 320,453	23	49,576	$ 6,464	25	18,237	$ 18	44
N. CAROLINA	116,323	32	52,586	2,212	37	5,082	23	42
N. DAKOTA	98,086	37	70,665	1,388	43	618	159	16
OHIO	724,748	12	41,222	17,582	6	10,652	68	30
OKLAHOMA	1,210,728	6	69,919	17,316	7	2,559	573	9
OREGON	76,516	40	96,981	789	48	2,091	37	36
PENNA.	1,231,485	5	45,333	27,165	3	11,794	104	22
R.I.	4,291	49	1,214	3,535	34	947	5	50
S. CAROLINA	82,313	39	31,055	2,651	35	2,591	32	39
S. DAKOTA	65,200	42	77,047	846	47	666	98	23
TENN.	269,814	26	42,244	6,387	22	3,924	69	29
TEXAS	7,211,551	1	267,338	26,975	4	11,197	644	6
UTAH	542,809	16	84,916	6,392	26	1,059	513	8
VERMONT	34,868	44	9,609	3,629	33	444	79	26
VIRGINIA	489,791	17	40,817	12,000	10	4,648	105	21
WASH.	109,806	35	68,192	1,610	40	3,409	32	38
W. VIRGINIA	1,430,632	4	24,181	59,163	2	1,744	820	5
WISC.	89,353	38	56,154	1,591	41	4,418	20	43
WYOMING	746,743	11	97,914	7,627	18	332	2,249	1
TOTAL	$32,217,000	--	3,615,055	8,912	--	202,455	159	--

Adapted From Reference No. 78

TABLE A-3
MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
ALABAMA	Coal (Bituminous)	20,813	200,430	Clays	2,850	7,512
	Stone	18,485	42,027	Iron Ore (GW)	366	1,912
				Sand and Gravel	6,352	8,530
				Bauxite		
				Mica Scrap		
				Phosphate Rock	(a)	(a)
				Salt		
				Stone (Dimension)		
ALASKA	Sand and Gravel	14,187	15,214	Barite	(b)	(b)
	Coal (Bituminous)	668	(b)	Gold	9(1)	506
				Lead	–	–
				Silver	<1(1)	<1(1)
				Stone	652	3,012
				Uranium	(a)	(a)
ARIZONA	Copper	909	930,419	Clays (4)	134	355
	Molybdenum	14	46,791	Coal (Bituminous)	(b)	(b)
	Sand & Gravel	24,842	32,420	Diatomite	(b)	(b)
				Gold	103(1)	6,036
				Gypsum	(b)	(b)
				Iron Ore	(b)	(b)
				Lead	2	530
				Mercury	–	–
				Silver	6,653(1)	11,210
				Stone	4,638	8,018
				Tungsten Ore	(b)	(b)
				Uranium	–	–

Adapted From Reference No. 78

KEY

(1) – Thousand Troy Ounces
(2) – 76 Pound Flasks
(3) – Excludes certain stone, itemized separately
(4) – Excludes certain clay, itemized separately
(5) – Excludes certain salt in brine, itemized separately
(a) – Production figures and values not disclosed
(b) – Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
ARIZONA				Zinc	10	3,589
				Clays (Bentonite	(a)	(a)
				Feldspar	(a)	(a)
				Mica		
ARKANSAS	Stone	16,317	25,020	Clays (4)	885	990
				Coal (Bituminous)	428	4,676
				Sand & Gravel	11,574	16,558
				Barite	(b)	(b)
				Clay (Kaolin)	(a)	(a)
				Bauxite	1,634	21,010
				Gypsum	(a)	(a)
				Mercury	(a)	(a)
CALIFORNIA	Sand & Gravel	117,288	162,619	Barite	4	34
				Boron	1,121	95,882
				Clays	2,706	7,387
				Copper	1	612
				Gold	4 (1)	233
				Gypsum	1,525	4,965
				Lead	1	347
				Magnesium Compounds	176	18,421
				Mercury	5,788 (2)	1,263
				Peat	29	620
				Salt	1,621	14,860
				Silver	175 (1)	296
				Stone	37,213	65,811
				Zinc	1	427
				Lignite	(a)	(a)

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(5) – Excludes certain salt in brine, itemized separately
(a) – Production figures and values not disclosed
(b) – Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $	ADDITIONAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $
CALIFORNIA	Sand & Gravel	117,288	162,619	Diatomite Feldspar Iron Ore Molybdenum Phosphate Rock Potassium Salt Sulfate Tungsten	(a)	(a)
COLORADO	Molybdenum	(b)	(b)	Clays	747	1,533
	Coal (Bituminous)	5,522	35,637	Copper	4	4,039
	Sand & Gravel	28,318	34,631	Feldspar	(b)	(b)
				Gold	61 (1)	3,580
				Gypsum	(b)	(b)
				Lead	31	9,423
				Mica Sheet	<1	7
				Peat	39	210
				Silver	3,664 (1)	6,174
				Stone	4,507	9,599
				Tungsten	(b)	(b)
				Uranium	<1	11,825
				Zinc	64	22,649
				Iron Ore Scrap Mica Salt	(a)	(a)
CONNECTICUT	Stone	8,719	19,695	Clays	157	292
	Sand & Gravel	6,763	11,270	Mica Scrap	2	(b)
	Feldspar	-	-	Feldspar	(a)	1,850

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(4) – Excludes certain clay, itemized separately
(5) – Excludes certain salt in brine, itemized separately
(a) – Production figures and values not disclosed
(b) – Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
DELAWARE	Sand & Gravel	2,257	2,660			
	Magnesium Compounds	-	-			
	Clays	15	9			
FLORIDA	Phosphate Rock	(a)	(a)	Clays (2)	922	10,336
	Stone (3)	53,093	81,621	Peat	45	362
				Sand & Gravel	20,752	15,025
				Kaolin	(a)	(a)
				Magnesium Compounds		
				Stone (Lime & Shell)		
				Titanium		
GEORGIA	Clays (2)	6,227	132,322	Barite	(b)	(b)
	Stone	37,074	82,484	Iron Ore		
	Sand & Gravel	3,816	4,729	Peat		
				Bauxite	(a)	(a)
				Fire Clay		
				Feldspar		
				Scrap Mica		
				Titanium		
HAWAII	Stone (3)	5,005	13,494	Clays	(b)	(b)
	Sand & Gravel	609	1,893	Salt	(a)	(a)
IDAHO	Silver	14,251(1)	24,012	Clays	57	415
	Lead	61	18,459	Copper	3	3,013

KEY

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(2) – 76 Pound Flasks
(3) – Excludes certain stone, itemized separately
(4) – Excludes certain clay, itemized separately
(5) – Excludes certain salt in brine, itemized separately
(a) – Production figures and values not disclosed
(b) – Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
IDAHO	Phosphate Rock	(b)	(b)	Gold	3(1)	169
	Zinc	39	13,720	Mercury	161(2)	35
				Peat	-	-
				Sand & Gravel	7,696	10,294
				Stone	3,094	7,042
				Tungsten	(b)	(b)
				Clays	(a)	(a)
				Iron Ore		
				Stone (Dimension)		
ILLINOIS	Coal (Bituminous)	65,523	402,481	Clays (4)	1,716	3,314
	Stone (3)	56,260	94,225	Lead	1	401
	Sand & Gravel	39,929	61,696	Peat	74	935
				Zinc	11	4,039
				Clay (Fuller's Earth)	(a)	(a)
				Silver	(a)	(a)
INDIANA	Coal (Bituminous)	25,949	144,688	Clays	1,419	2,465
	Stone	27,511	50,919	Peat	45	478
	Sand & Gravel	27,978	33,290	Gypsum	(a)	(a)
IOWA	Stone	27,457	48,642	Clays	1,047	2,643
	Sand & Gravel	17,107	20,140	Coal (Bituminous)	851	4,138
	Gypsum	1,380	5,714	Clay (Fire)	(a)	(a)
				Peat		
				Stone (Dimension)		

KEY

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(2) - 76 Pound Flasks
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(4) - Excludes certain clay, itemized separately
(5) - Excludes certain salt in brine, itemized separately
(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued
MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
KANSAS				Clays	1,170	1,457
				Coal (Bituminous)	1,227	7,835
				Lead	-	-
				Salt (5)	1,369	20,562
				Sand & Gravel	11,591	10,920
				Stone (3)	14,547	23,849
				Zinc	-	-
				Clays	(a)	(a)
				Gypsum		
				Salt (Brine)		
KENTUCKY	Coal (Bituminous)	121,188	824,691	Clays (4)	920	1,406
	Stone (3)	34,279	59,690	Sand & Gravel	8,485	11,967
				Zinc	2	632
				Clay (Ball)	(a)	(a)
				Stone (3)	(a)	(a)
LOUISIANA	Sulfur	4,217	(b)	Clays	1,000	1,454
				Salt	13,514	67,464
				Sand & Gravel	18,920	26,996
				Stone (3)	9,190	14,836
				Gypsum	(a)	(a)
				Stone (Miscellaneous)	(a)	(a)
MAINE	Sand & Gravel	11,818	7,535	Clays (4)	40	57
	Stone	1,078	2,996	Copper	1	1,249
	Zinc	6	2,066	Lead	<1	26

KEY

(1) - Thousand Troy Ounces
(2) - 76 Pound Flasks
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(5) - Excludes certain salt in brine, itemized separately
(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $	ADDITIONAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $
MAINE				Peat	2	99
				Silver	16 (1)	27
				Clays (Miscellaneous)	(a)	(a)
				Feldspar	(a)	(a)
MARYLAND	Stone	19,431	41,973	Clays (4)	1,104	2,121
	Sand & Gravel	12,594	26,557	Peat	3	29
	Coal (Bituminous)	1,640	8,961	Clays (Miscellaneous) Diatomite Potash	(a)	(a)
MASSACHUS-ETTS	Sand & Gravel	18,883	25,655	Peat	(b)	(b)
	Stone	7,990	23,500			
	Clays	219	419			
MICHIGAN	Iron Ore	14,215	177,461	Clays	2,514	3,715
	Copper	67	68,874	Gypsum	1,650	7,267
	Sand & Gravel	59,467	65,445	Magnesium Compounds (from sea & brine)	378	31,484
				Peat	219	2,190
				Salt	4,358	50,761
				Silver	785 (1)	1,323
				Stone	39,754	50,317
				Potassium Salts	(a)	(a)
MINNESOTA	Iron Ore	56,666	601,869	Clays (4)	167	251

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(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $	ADDITIONAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $
MINNESOTA	Sand & Gravel	36,792	33,454	Manganiferous	119	(b)
	Stone	5,757	16,318	Peat	(b)	(b)
				Clays (Miscellaneous)	(a)	(a)
MISSISSIPPI	Sand & Gravel	13,419	16,133	Clays	1,919	7,837
				Stone	1,135	1,199
				Magnesium Compounds	(a)	(a)
MISSOURI	Lead	489	147,113	Barite	213	3,637
	Stone (3)	42,473	63,219	Clays (4)	2,571	9,096
	Iron Ore	3,018	(b)	Coal (Bituminous)	4,551	23,667
				Copper	12	11,785
				Sand & Gravel	10,082	14,806
				Silver	1,972 (1)	3,322
				Zinc	62	21,983
MONTANA	Copper	123	126,064	Clays (4)	304	1,590
	Sand & Gravel	10,116	17,149	Gold	24 (1)	1,390
	Coal (Bituminous and Lignite)	8,221	16,690	Iron Ore (GW)	10	(b)
				Lead	< 1	86
				Manganese	< 1	(b)
				Silver	3,325 (1)	5,603
				Stone	4,074	5,627
				Tungsten	(b)	(b)
				Zinc	< 1	4
				Clays (Miscellaneous) Gypsum Peat	(a)	(a)

KEY

(1) – Thousand Troy Ounces
(2) – 76 Pound Flasks
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(4) – Excludes certain clay, itemized separately
(5) – Excludes certain salt in brine, itemized separately
(a) – Production figures and values not disclosed
(b) – Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
MONTANA				Phosphate Rock Stone	(a)	(a)
NEBRASKA	Sand & Gravel Stone	13,720 4,251	15,063 7,645	Clays	115	143
NEVADA	Copper Gold Sand & Gravel Diatomite	101 420 (1) 10,081	103,545 24,597 12,636	Barite Clays Gypsum Iron Ore Lead Mercury Silver Stone Tungsten Zinc Brucite Diatomite Magnesite Molybdenum Salt	317 40 860 (b) <1 810 (2) 595 (1) 3,329 <1 - (a)	2,659 183 2,871 (b) <1 177 1,003 5,926 (b) - (a)
NEW HAMPSHIRE	Sand & Gravel Stone Clays	6,020 528 51	6,256 3,743 70	Feldspar Mica Scrap	(a) (a)	(a) (a)
NEW JERSEY	Stone (3) Sand & Gravel	18,651 17,679	53,083 38,020	Clays Peat	212 (b)	856 (b)

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(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
NEW JERSEY	Zinc	38	13,524	Manganiferous	(a)	(a)
	Magnesium Compounds	(a)	(a)	Stone (Dimension)		
				Titanium		
NEW MEXICO	Copper	168	172,067	Clays (4)	65	108
	Potassium Salt	2,296	91,115	Coal (Bituminous	8,248	29,794
				Feldspar	-	-
				Gold	15 (1)	873
				Gypsum	(b)	(b)
				Iron Ore	(b)	(b)
				Lead	4	1,077
				Manganese	-	-
				Peat	2	46
				Salt	(b)	(b)
				Sand & Gravel	7,600	8,553
				Silver	1,017 (1)	1,713
				Stone	2,768	5,499
				Uranium	5	68,091
				Zinc	13	4,521
				Mica Scrap		
				Molybdenum	(a)	(a)
				Stone		
NEW YORK	Stone	38,138	77,825	Clays (4)	1,601	1,919
	Salt	5,604	43,866	Gypsum	486	3,079
	Sand & Gravel	26,722	36,952	Lead	1	327
				Mercury	(b)	(b)
				Peat	15	200
				Silver	25 (1)	42
				Zinc	(a)	(a)

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(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
NEW YORK				Clays (Ball)	(a)	(a)
				Iron Ore		
				Titanium		
N. CAROLINA	Stone	32,297	62,741	Clays (4)	3,862	4,473
	Sand & Gravel	13,485	14,615	Feldspar	440	6,030
	Phosphate Rock			Mica Scrap	91	2,942
				Mica Sheet	(a)	(a)
				Clay (Kaolin)		
				Copper		
				Gold		
				Iron Ore		
				Lead		
				Phosphate Rock		
				Silver		
				Tungsten		
				Zinc		
N. DAKOTA	Coal (Lignite)	6,632	13,416	Stone	-	-
	Sand & Gravel	6,681	5,757	Clays	(a)	(a)
				Peat (1970-71)		
				Salt		
OHIO	Coal (Bituminous)	50,967	303,819	Clays	4,125	11,273
	Stone	48,498	90,821	Peat	4	67
				Salt	6,147	47,710
				Sand & Gravel	43,506	59,932
				Gypsum	(a)	(a)

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(5) - Excludes certain salt in brine, itemized separately
(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued
MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
OKLAHOMA				Clays (4)	938	1,398
				Coal (Bituminous)	2,624	19,112
				Gypsum	1,196	3,888
				Lead	-	-
				Salt	(b)	(b)
				Sand & Gravel	7,901	11,138
				Stone	19,448	26,574
				Clay (Bentonite)	(a)	(a)
				Copper		
				Silver		
OREGON	Sand & Gravel	24,489	34,981	Clays	151	238
	Stone	10,915	18,380	Copper	(b)	(b)
				Diatomite		
				Gold		
				Lead	-	-
				Mercury	-	-
				Silver	2 (1)	4
				Copper	(a)	(a)
				Bauxite		
				Clay (Fire)		
				Tungsten		
PA.	Coal			Clays	2,682	15,829
	Stone	67,307	124,340	Copper	3	2,673
	Sand & Gravel	18,757	36,804	Mica Scrap	(b)	(b)
	Coal (Anthracite)	7,106	85,251	Peat	22	320
	Coal (Bituminous)	75,939	694,267	Zinc	18	6,512

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(a) - Production figures and values not disclosed
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Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $	ADDITIONAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $
PENNSYLVANIA				Clay-Kaolin Gold Iron Ore Silver	(a)	(a)
RHODE ISLAND	Sand & Gravel	2,079	3,336	Other Non-metals	(a)	932
	Stone (3)	329	23			
S. CAROLINA	Stone	12,482	21,819	Feldspar Scrap Mica Peat Stone (Misc.)	(a)	(a)
	Sand & Gravel	7,916	12,121			
	Clays	2,221	11,268			
S. DAKOTA	Gold	407 (1)	23,875	Clays (4)	185	156
	Sand & Gravel	12,748	14,793	Feldspar	11	150
	Stone	2,665	10,864	Gypsum	24	43
				Lead	-	-
				Mica Scrap	(b)	(b)
				Silver	100 (1)	168
				Zinc	-	-
				Uranium	(a)	(a)
TENNESSEE	Coal (Bituminous)	11,260	81,386	Barite	(b)	(b)
	Stone	35,942	55,512	Clays (4)	1,718	7,719
	Zinc	102	36,111	Copper	11	11,581

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(a) - Production figures and values not disclosed
(b) - Withheld to avoid disclosing individual company confidential data

Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
TENNESSEE				Gold	<1(1)	10
				Phosphate Rock	2,154	10,732
				Sand & Gravel	10,839	15,328
				Silver	83(1)	141
				Clay (Fuller's Earth)	(a)	(a)
TEXAS				Clays	5,175	11,554
				Coal (Lignite)	4,045	(b)
				Gypsum	1,542	5,284
				Salt	9,744	36,544
				Sand & Gravel	35,151	56,328
				Stone(4)	49,314	66,573
				Sulfur	4,309	(b)
				Iron Ore Magnesium Compounds Mercury Uranium	(a)	(a)
UTAH	Copper	260	265,735	Clays (4)	266	790
	Coal (Bituminous)	4,802	42,868	Iron Ore	2,003	(b)
	Gold	362(1)	21,237	Lead	21	6,224
				Manganiferous	-	-
				Salt	660	4,955
				Sand & Gravel	14,619	17,071
				Silver	4,300(1)	7,245
				Stone	3,384	6,005
				Tungsten	(b)	(b)
				Uranium	<1	9,425

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(a) - Production figures and values not disclosed
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Table A-3 Continued
MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $	ADDITIONAL MINERALS	1972 PRODUCTION QUANTITY (1,000 Tons)	1972 PRODUCTION VALUE $
UTAH				Zinc	22	7,758
				Clays (Miscellaneous) Gypsum Magnesium Compounds Molybdenum Phosphate Rock Potash	(a)	(a)
VERMONT	Stone	3,300	26,170	Peat	<1	1
	Sand & Gravel	3,302	3,214	Clays	(a)	(a)
VIRGINIA	Coal (Bituminous)	34,028	344,061	Clays	1,634	1,783
	Stone	39,986	74,090	Lead	3	1,034
	Sand & Gravel	14,085	21,696	Zinc	17	5,960
				Feldspar Gypsum Iron Ore Salt Titanium	(a)	(a)
WASHINGTON	Sand & Gravel	23,065	26,069	Clays (4)	264	584
	Stone (3)	14,712	23,764	Copper	(b)	(b)
	Coal (Bituminous)	2,635	17,424	Gypsum	5	13
				Lead	3	772
				Peat	18	89
				Silver	221 (1)	372
				Zinc	6	2,301

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Table A-3 Continued

MINERAL PRODUCTION, BY STATE

STATE	PRINCIPAL MINERALS	1972 PRODUCTION		ADDITIONAL MINERALS	1972 PRODUCTION	
		QUANTITY (1,000 Tons)	VALUE $		QUANTITY (1,000 Tons)	VALUE $
WASHINGTON				Bauxite Clays (Miscellaneous) Diatomite Gold Uranium	(a)	(a)
W. VIRGINIA	Coal (Bituminous)	123,743	1,275,813	Clays (4)	274	403
	Stone (3)	11,649	21,293	Salt	1,232	5,963
				Sand & Gravel	5,765	15,031
				Clay (Fire)	(a)	(a)
				Stone (3)	(a)	(a)
WISCONSIN	Sand & Gravel	36,430	31,324	Clays	4	7
	Stone	19,394	29,681	Lead	<1	228
	Iron Ore (GW)	993	(b)	Peat	2	179
				Zinc	7	2,440
WYOMING	Uranium	4	53,827	Clays	1,873	18,509
				Coal (Bituminous)	10,928	40,898
				Gypsum	(b)	(b)
				Iron Ore	2,274	(b)
				Sand & Gravel	9,098	14,916
				Stone	3,549	5,768
				Copper Feldspar Gold Phosphate Rock	(a)	(a)

Adapted From Reference No. 78

KEY

(1) – Thousand Troy Ounces
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Table A-4
MINERAL PRODUCTION AND
PRODUCING STATES, BY COMMODITY

MINERALS		1972 PRODUCTION TONS	PRINCIPAL PRODUCING STATES	SECONDARY PRODUCING STATES
METALS	Bauxite	2,029,440	Ark., Ala., Ga.,	
	Copper	1,664,840	Ariz., Utah., N. Mex., Mont.	Calif., Colo., Idaho, Maine, Mich., Md., Nev., Okla., Oreg., Pa., Tenn., Wash.
	Gold	1,449,943(1)	Nev., S.Dak., Utah, Ariz.	Alaska, Calif., Colo., Idaho, Mont., N. Mex., Oregon, Tenn., Wash.
	Iron Ore	87,230,080	Minn., Mich., Calif., Mo.	Ala., Arizo., Colo., Ga., Idaho, Mont., Nev., N. Mex., NY., Nc., Pa., Tex., Utah, Wisc., Wyo.
	Lead	618,915	Mo., Idaho, Colo., Utah.	Ariz., Calif., Ill., Maine, Mont., Nev., N. Mex., NY., Va., Wash., Wisc.
	Manganese	147,739	Mont.	
	Mercury	7,286(2)	Calif., Nev., Alaska Idaho.	NY, Texas
	Molybdenum	51,099	Colo., Ariz., N. Mex., Utah.	Calif., Nev.
	Silver	37,233,000(1)	Idaho, Ariz., Utah, Colo.	Alaska, Calif., Ill., Maine., Mich., Mo., Mont., Nev., N. Mex. NY., Okla., Oregon, S. Dak., Tenn., Wash
	Titanium	725,728	NY., Fla., N.J., Ga.	

Adapted from Reference No. 78

KEY

NA - NOT APPLICABLE
(1) - VALUES ARE SHOWN IN TROY OUNCES
(2) - VALUE IS SHOWN IN 76 POUND FLASKS
(3) - MAGNESIUM COMPOUNDS FROM SEA WATER & BRINE
(4) - EXCLUDES ABRASIVE STONE, BITUMINOUS LIMESTONE, BITUMINOUS SANDSTONE, AND SOAPSTONE

Table A-4 Continued

	MINERALS	1972 PRODUCTION TONS	PRINCIPAL PRODUCING STATES	SECONDARY PRODUCING STATES
METALS	Tungsten	7,401	Calif., Colo., Nev., Mont.	Ariz., Idaho, Oregon, Utah, Wash.
	Uranium	12,879	N. Mex., Wyo., Tex., Col.	Alaska, S. Dak., Utah, Wash,
	Zinc	478,318	Tenn., Colo., Mo., NY.	Ariz., Calif., Idaho, Ill., Ky., Maine, Mont., N.J., N. Mex., Okla., Pa., Utah, Va., Wash., Wisc.
NONMETALS	Barite	906,000	Nev., Mo., Ark., Alaska.	Calif., Ga., Tenn.
	Boron	1,121,000	Calif.	
	Clays	59,456,000	Ga., Tex., Ohio, N.C.	All States Except: Alaska, R.I., Vt.
	Diatomite	576,089	Calif., Nev., Wash., Ariz.	Oregon
	Feldspar	732,439	N.C., Calif., Conn., S.C.	Ariz., Colo., Ga., S. Dak., Wyo.
	Gypsum	12,328,000	Mich., Tex., Calif., Iowa.	Ariz., Ark., Colo., Ind., Kansas, La., Mont., Nev., N. Mex., NY., Ohio, Okla., S. Dak., Utah, Va., Wash., Wyo.
	Magnesite and Brucite	NA NA	Nev.	

Adapted from Reference No. 78

KEY

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(1) - VALUES ARE SHOWN IN TROY OUNCES
(2) - VALUE IS SHOWN IN 76 POUND FLASKS
(3) - MAGNESIUM COMPOUNDS FROM SEA WATER & BRINE
(4) - EXCLUDES ABRASIVE STONE, BITUMINOUS LIMESTONE, BITUMINOUS SANDSTONE, AND SOAPSTONE

Table A-4 Continued

	MINERALS	1972 PRODUCTION TONS	PRINCIPAL PRODUCING STATES	SECONDARY PRODUCING STATES
NON METALS	Magnesium Compounds	729,472(3)	Texas, Utah, Mich., Calif., Fla., N.J.	Del., Miss., Texas, Utah.
	Mica	160,007	N.C., Ala., Ga., S.C., Colo.	Ariz., Conn., N. Mex., Pa., S. Dak.
	Phosphate Rock	40,831,000	Fla., Idaho, Tenn., N.C.	Mont., Utah, Wyo.
	Potassium Salt	2,659,000	N. Mex., Calif., Utah	
	Salt	45,022,000	La., Tex., Ohio, NY.	Ala., Calif., Colo., Hawaii, Kansas, Mich., Nev., N. Mex., N. Dak., Okla., Utah, Va., W. Va.
	Sand & Gravel	913,375,000	Calif., Mich., Ohio, Ill.	All Other States
	Stone	923,852,000(4)	Pa., Ill., Fla., Tex.	All Except Dela.
	Sulfur	8,526,560	Tex., La.	
FOSSIL FUELS	Coal (Bituminous and Lignite)	595,386,000	W.Va., Ky., Pa., Ill.,	Ala., Alaska, Ariz., Ark., Colo., Ind., Iowa, Kansas, Md., Mo., Mont., N. Mex., N.Dak., Ohio, Okla., Tenn., Tex., Utah, Va., Wash., Wyo.
	Coal (Anthracite)	7,106,000	Pa.	
	Peat	607,000	Mich., Ill., Fla., Ind.	Calif., Colo., Ga., Iowa, Maine, Md., Mass., Minn., Mont., N.J., N. Mex., NY., Ohio, Pa., S.C., Vt. Wash., Wisc.
	Shale Oil	Currently Not Being Commercially Produced		

Adapted from Reference No. 78

KEY

NA - NOT APPLICABLE
(1) - VALUES ARE SHOWN IN TROY OUNCES
(2) - VALUE IS SHOWN IN 76 POUND FLASKS
(3) - MAGNESIUM COMPOUNDS FROM SEA WATER & BRINE
(4) - EXCLUDES ABRASIVE STONE, BITUMINOUS LIMESTONE, BITUMINOUS SANDSTONE, AND SOAPSTONE

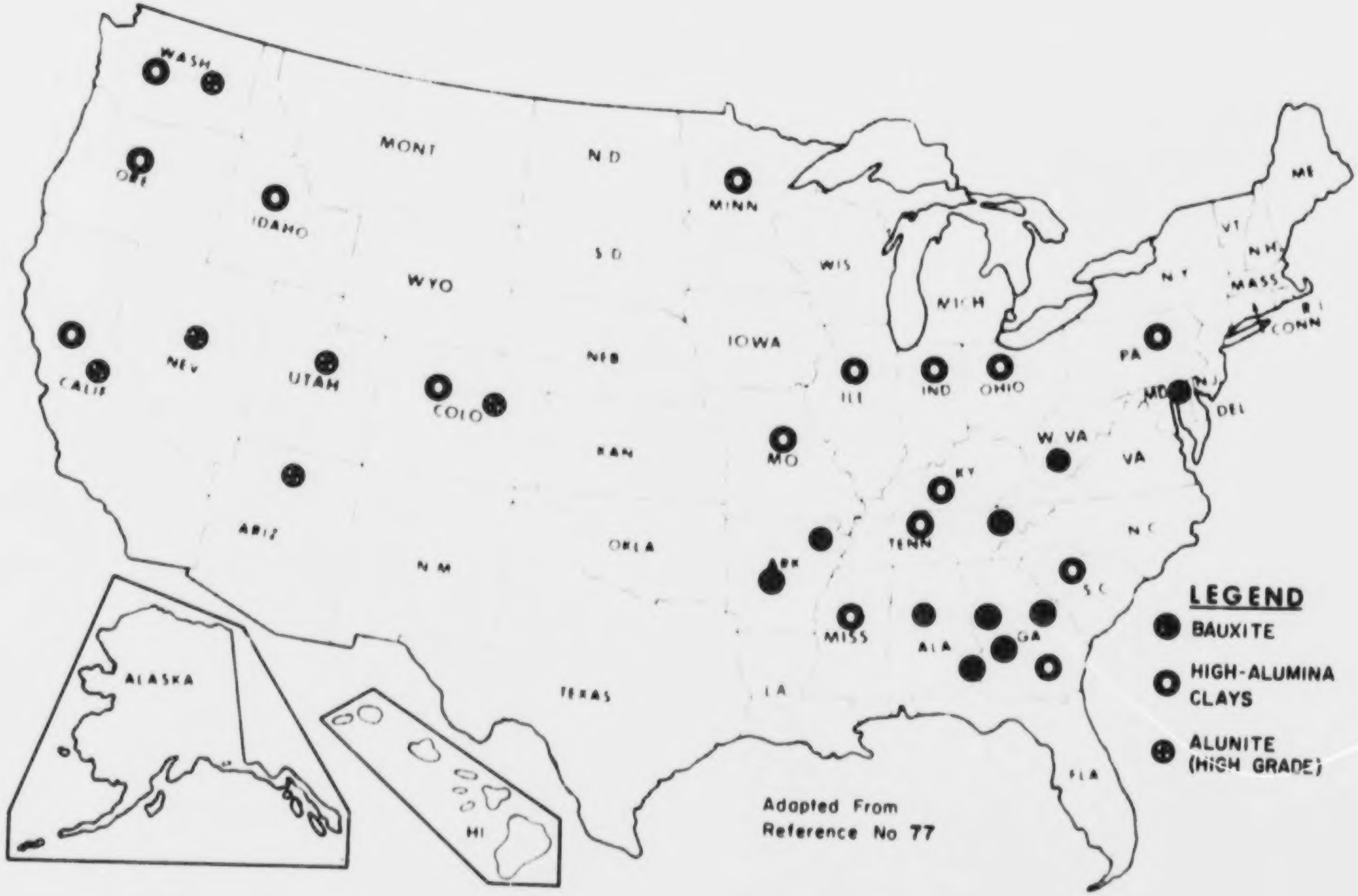
Table A-5

NUMBER OF MINES IN 1972 BY COMMODITY
AND MAGNITUDE OF CRUDE ORE PRODUCTION(1)

	MINERALS	Total No. of Mines	Number of Mines Producing				
			Less than 10,000 T.	10,000 to 100,000 T.	100,000 to 1,000,000 T.	1,000,000 to 10,000,000 T.	More than 10,000,000 T.
METALS	Bauxite	16	3	9	4	-	-
	Copper	73	18	9	15	23	8
	Gold:						
	Lode	29	22	3	2	2	-
	Placer	42	34	7	1	-	-
	Iron Ore	58	9	4	15	26	-
	Lead	29	12	3	9	5	-
	Mercury	19	16	3	-	-	-
	Silver	49	41	6	2	-	-
	Titanium	6	-	-	-	6	-
	Tungsten	39	37	1	1	-	-
	Uranium	189	111	61	17	-	-
	Zinc	32	2	9	21	-	-
	TOTAL	581	305	115	87	62	12
NONMETALS	Barite	30	3	11	16	-	-
	Boron	2	-	1	-	1	-
	Clays	1,064	317	579	168	-	-
	Diatomite	11	4	6	1	-	-
	Feldspar	22	5	12	5	-	-
	Gypsum	65	6	15	44	-	-
	Mica Scrap	18	9	7	2	-	-
	Mica Sheet	1	1	-	-	-	-
	Phosphate R.	45	6	7	12	18	2
	Potassium S.	7	-	-	-	7	-
	Salt	18	2	1	8	7	-
	Sand & Gravel	6,694	1,125	3,365	2,098	102	-
	Stone:						
	Crushed	4,448	1,007	1,718	1,550	172	1
	Dimension	391	359	32	-	-	-
	TOTAL	12,812	2,844	5,754	3,904	307	3
FOSSIL FUEL	Coal	9,758	1,310	2,562	924	83	-
	TOTAL	9,758	1,310	2,562	924	83	-
GRAND TOTAL		23,151	4,459	8,431	4,915	452	15

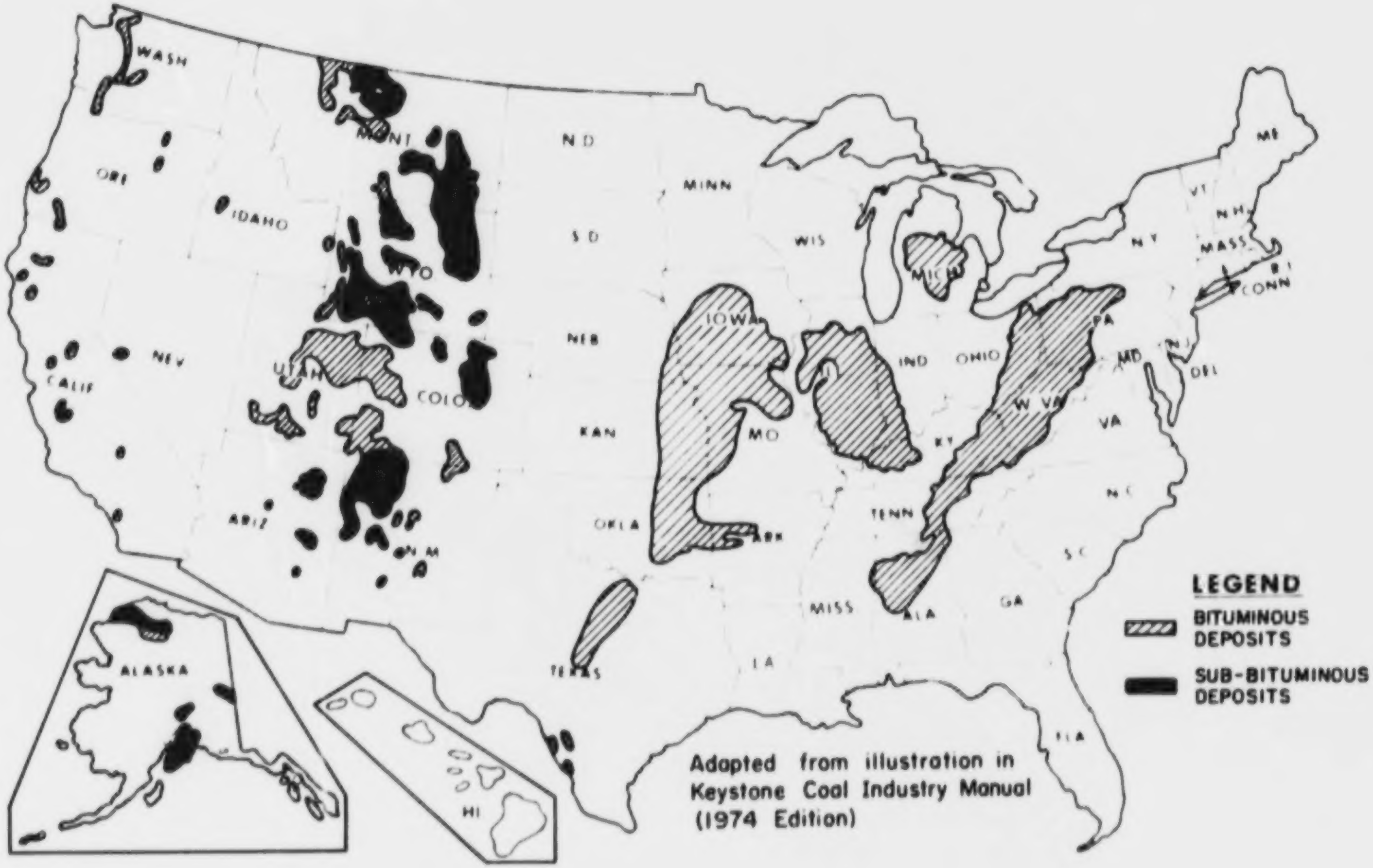
Adapted From Reference No. 36, 78

(1) Excludes wells, ponds, or pumping operations



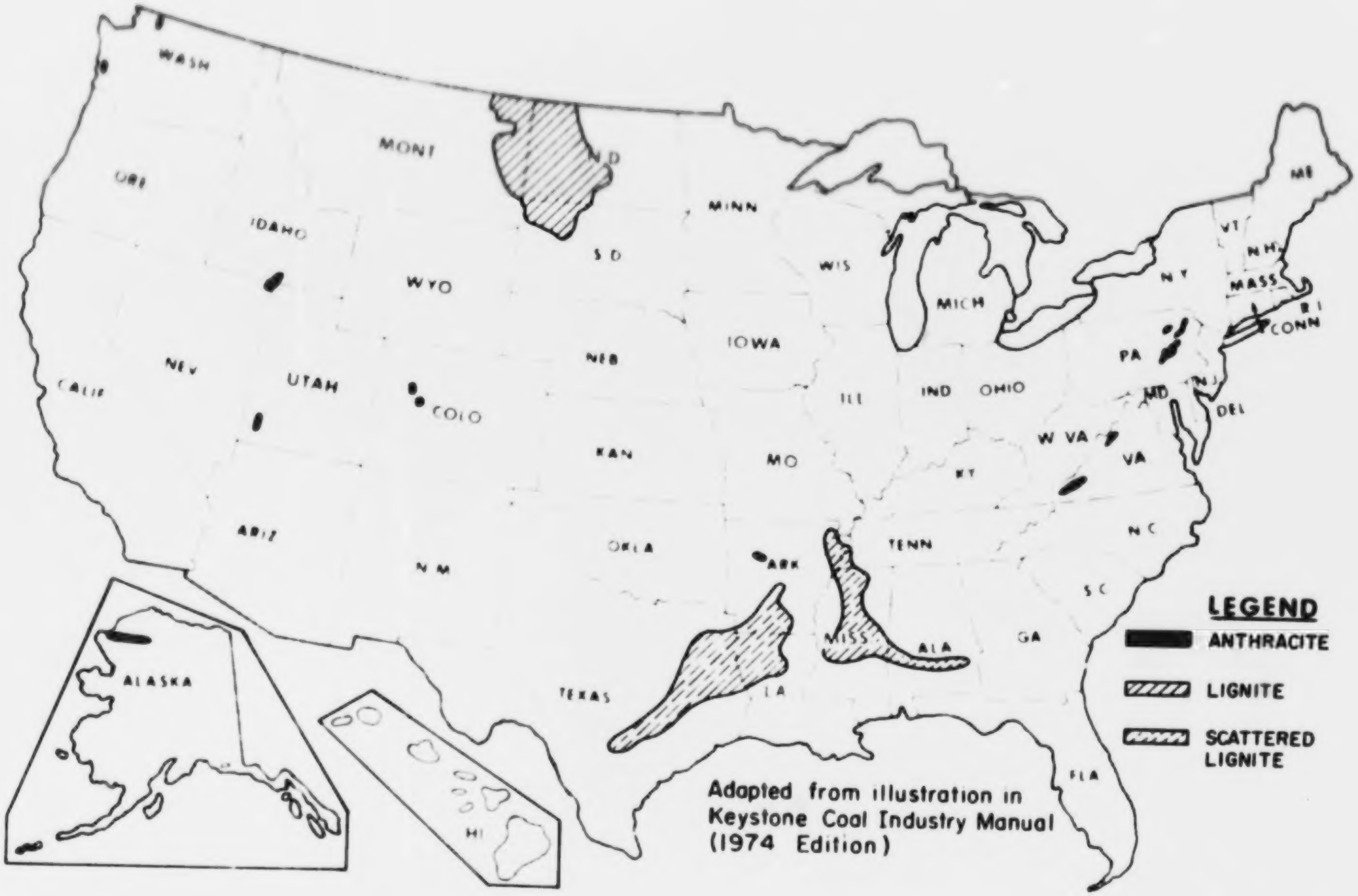
Adapted From
Reference No 77

Figure A-1. Bauxite and other sources of aluminum reserves.



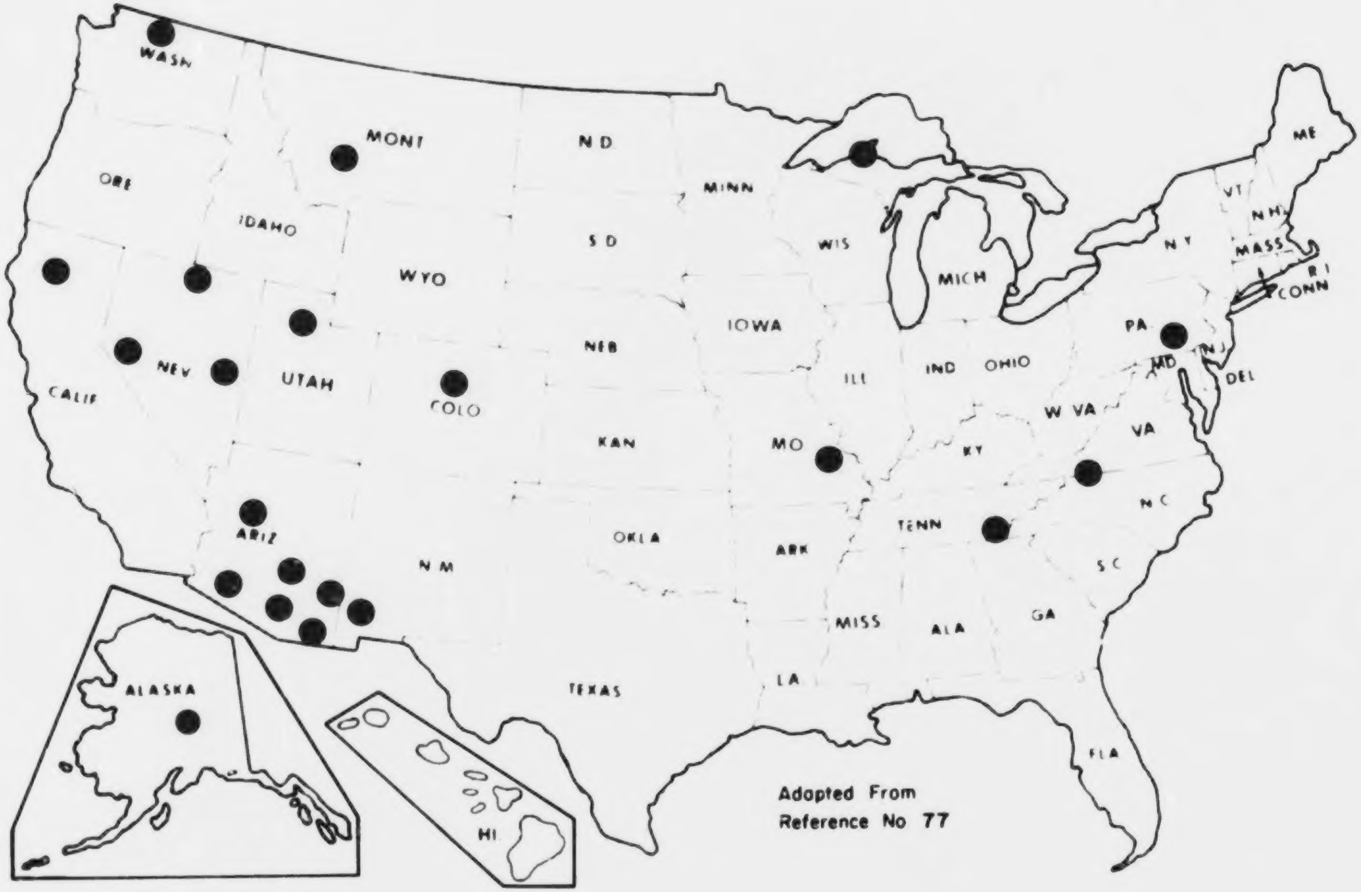
Adapted from illustration in Keystone Coal Industry Manual (1974 Edition)

Figure A-2. Sources of bituminous & sub-bituminous coal reserves.



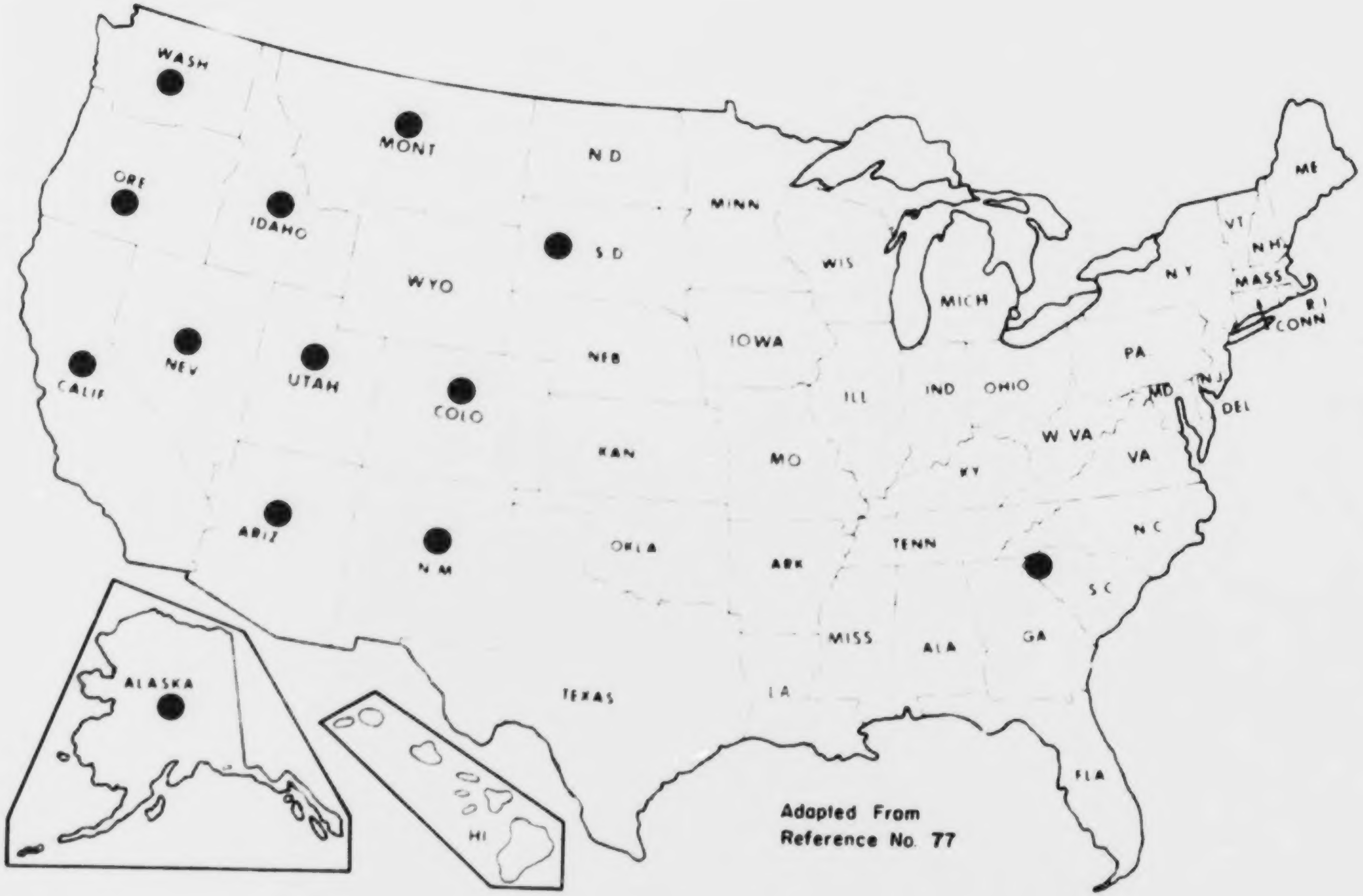
Adapted from illustration in Keystone Coal Industry Manual (1974 Edition)

Figure A-3. Sources of anthracite & lignite coal reserves.



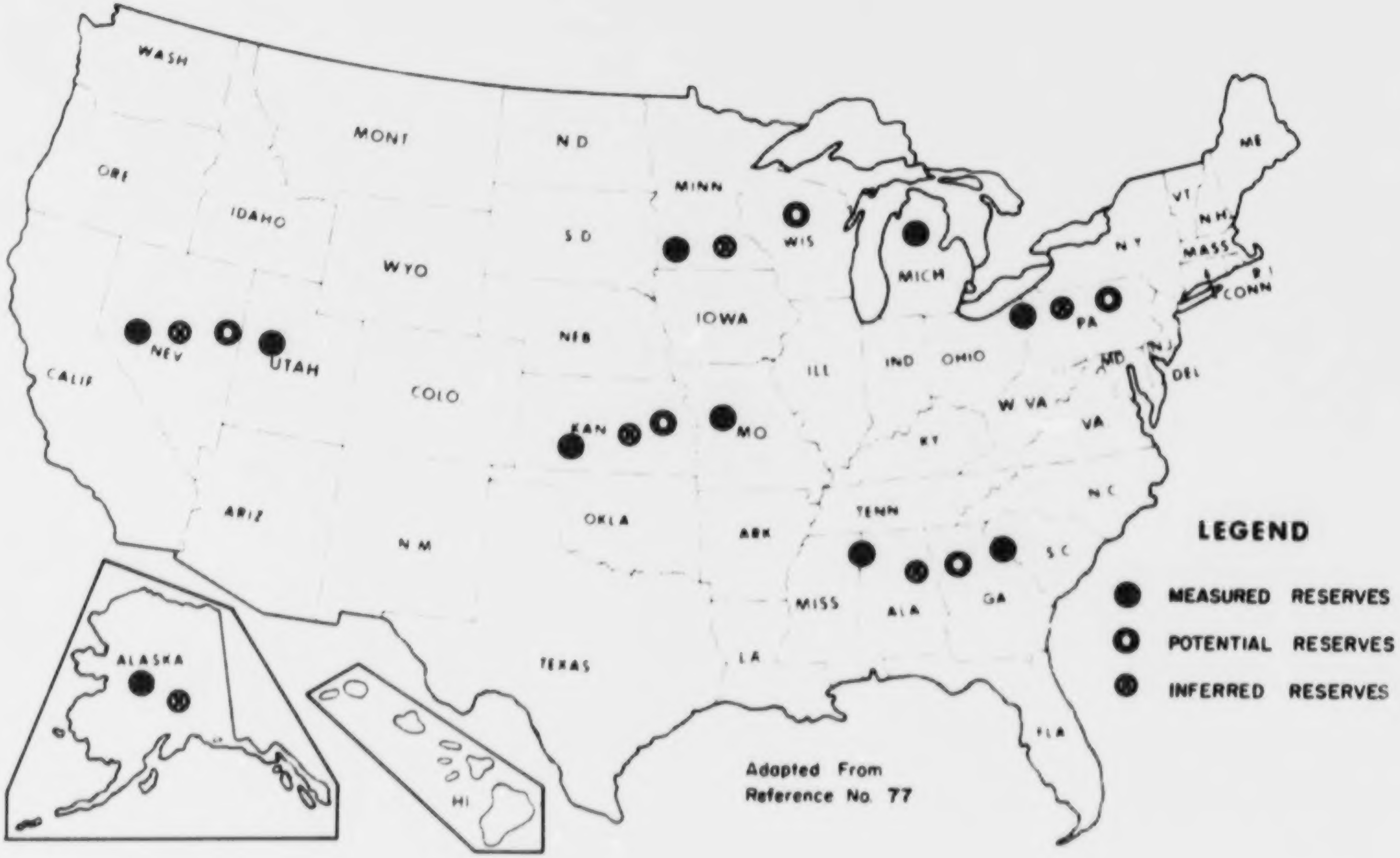
Adopted From
Reference No 77

Figure A-4. Sources of copper reserves.



Adapted From
Reference No. 77

Figure A-5. Sources of gold reserves.



Adapted From
Reference No. 77

Figure A-6. Sources of iron ore reserves.

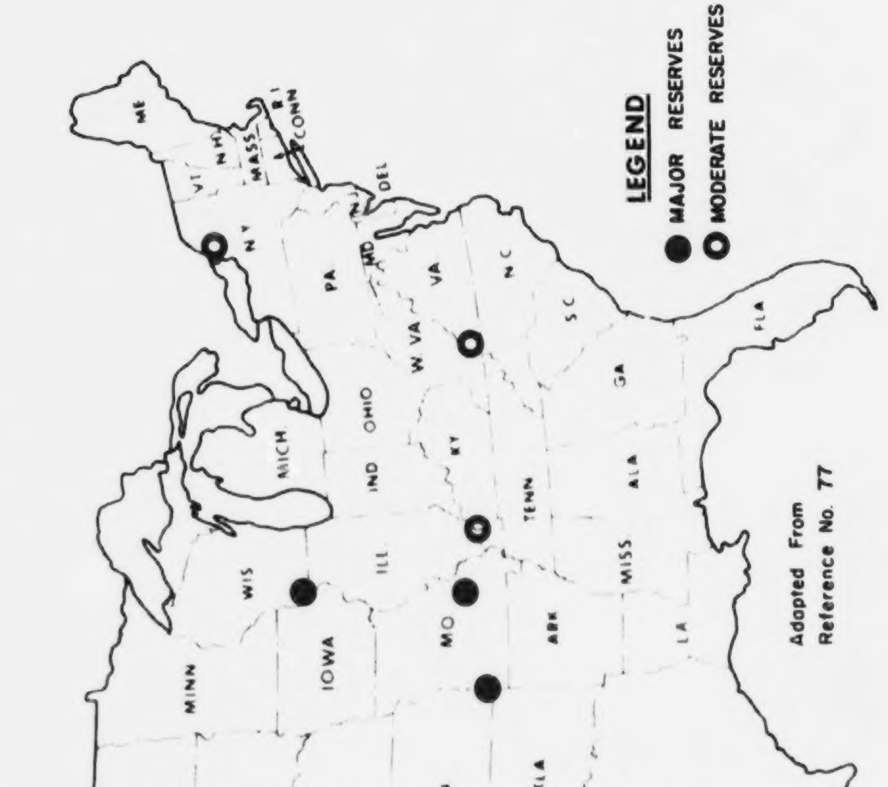
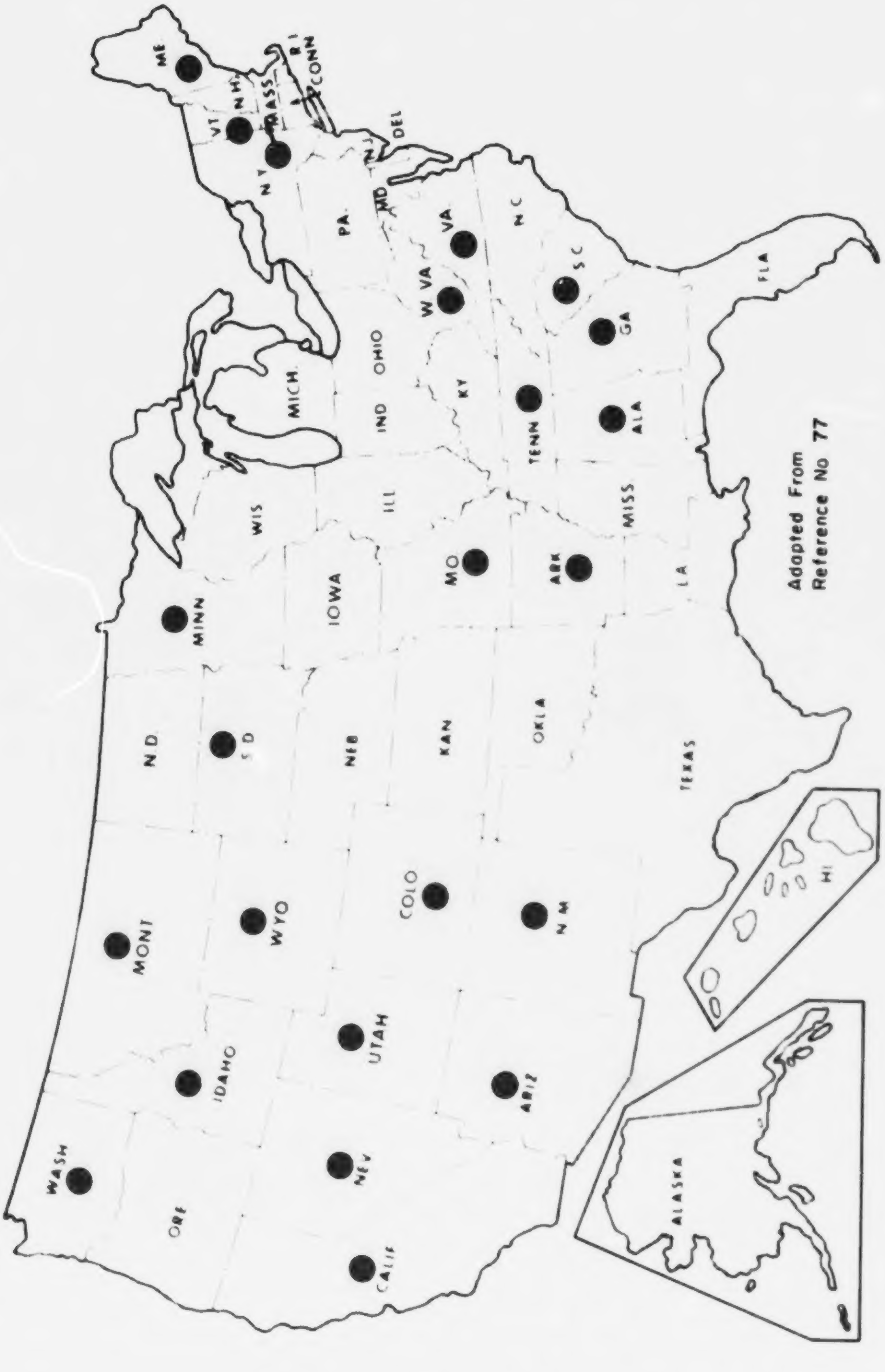


Figure A-7. Sources of lead reserves



Adapted From Reference No 77

Figure A-8. Sources of manganese reserves.

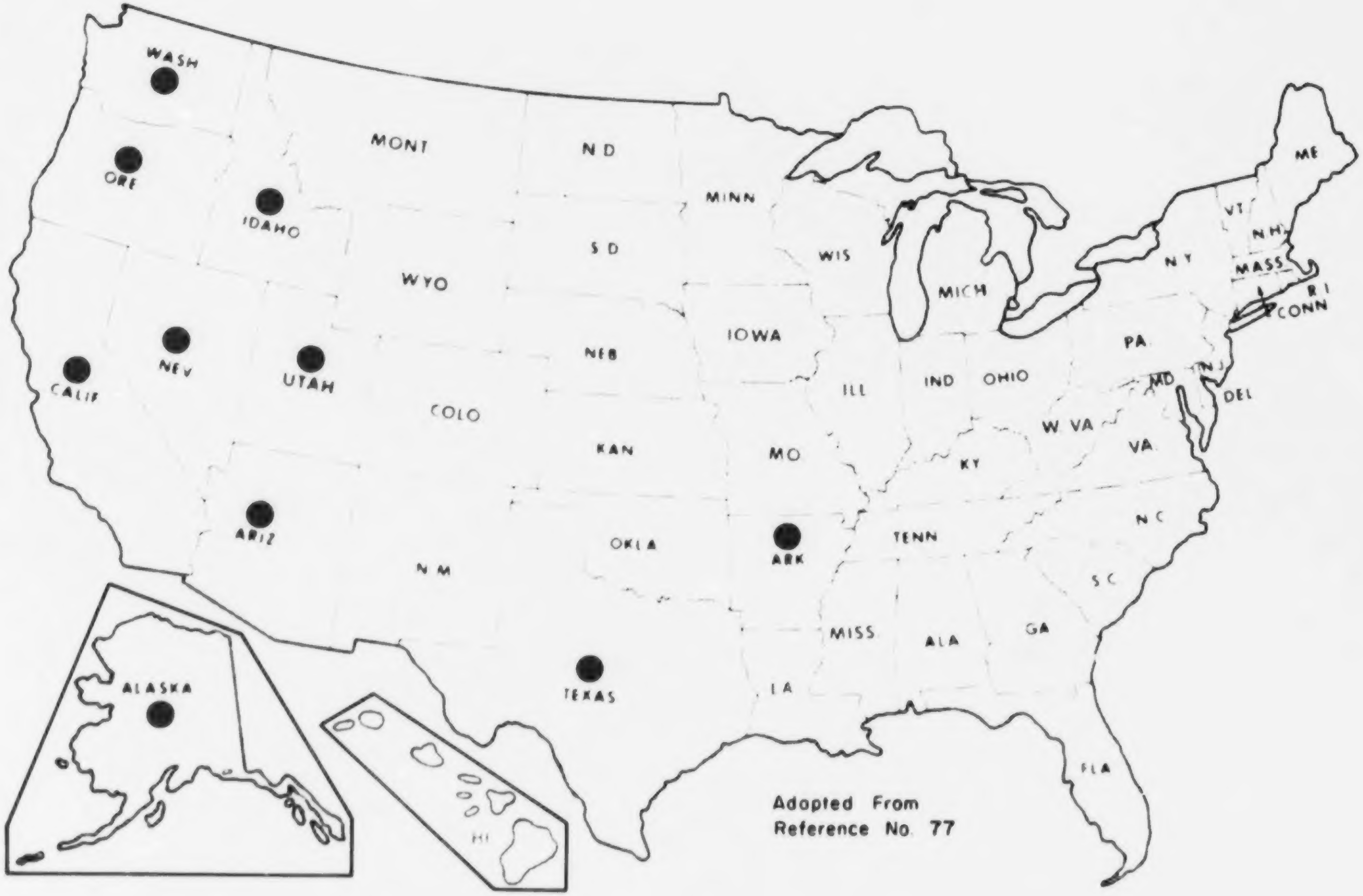


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Figure A-9. Sources of mercury reserves.

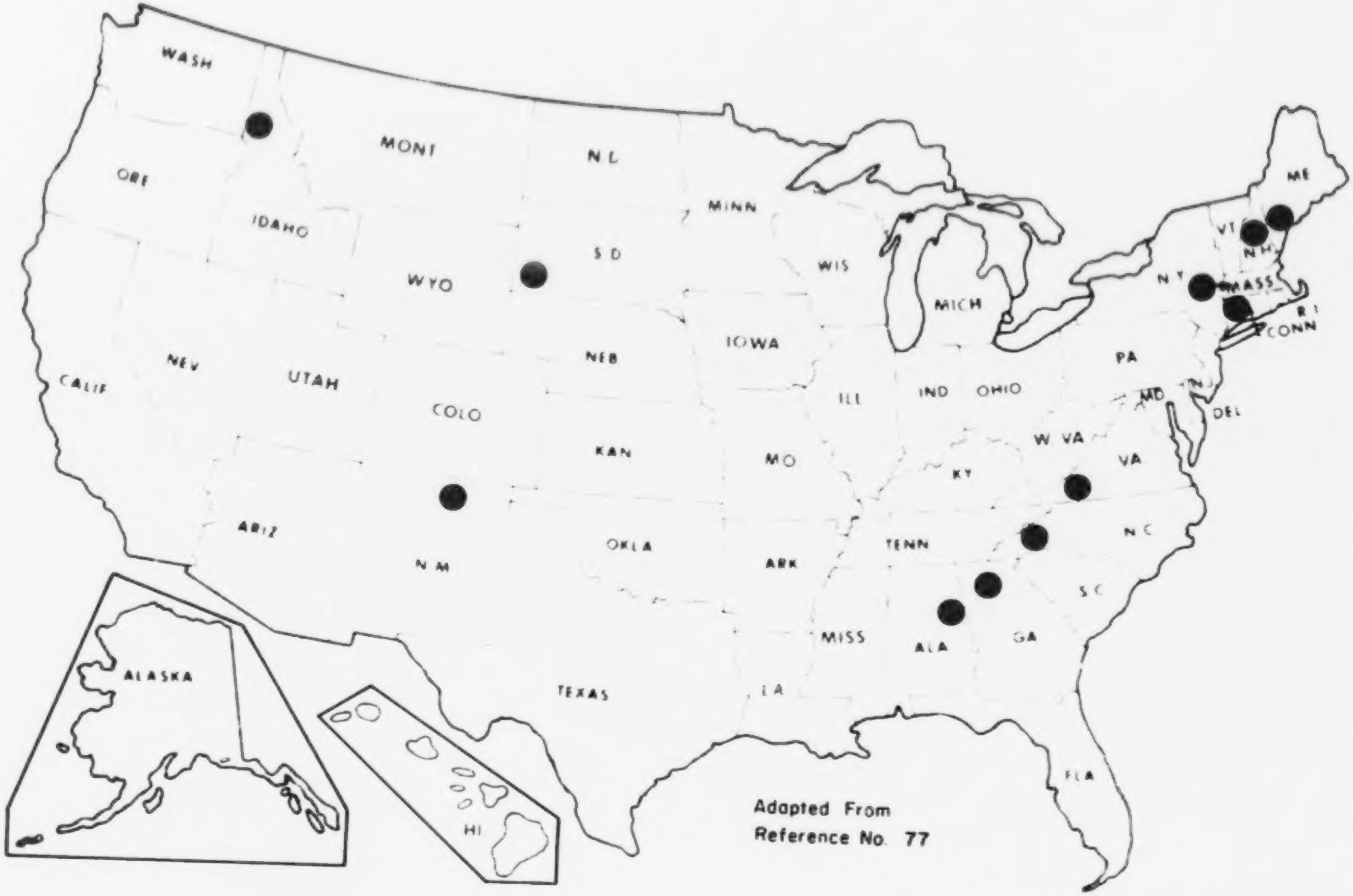

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Figure A-10. Sources of mica reserves

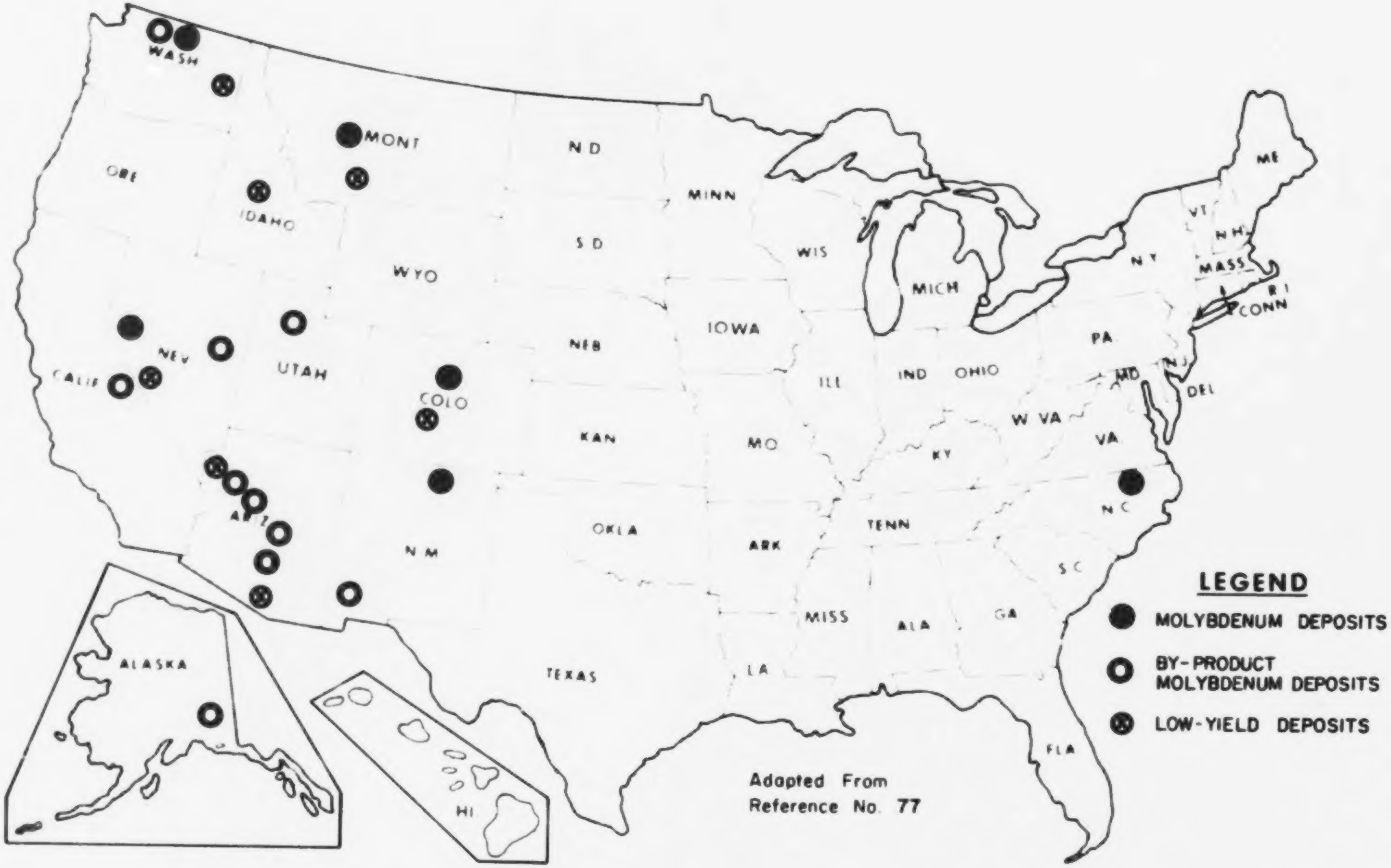

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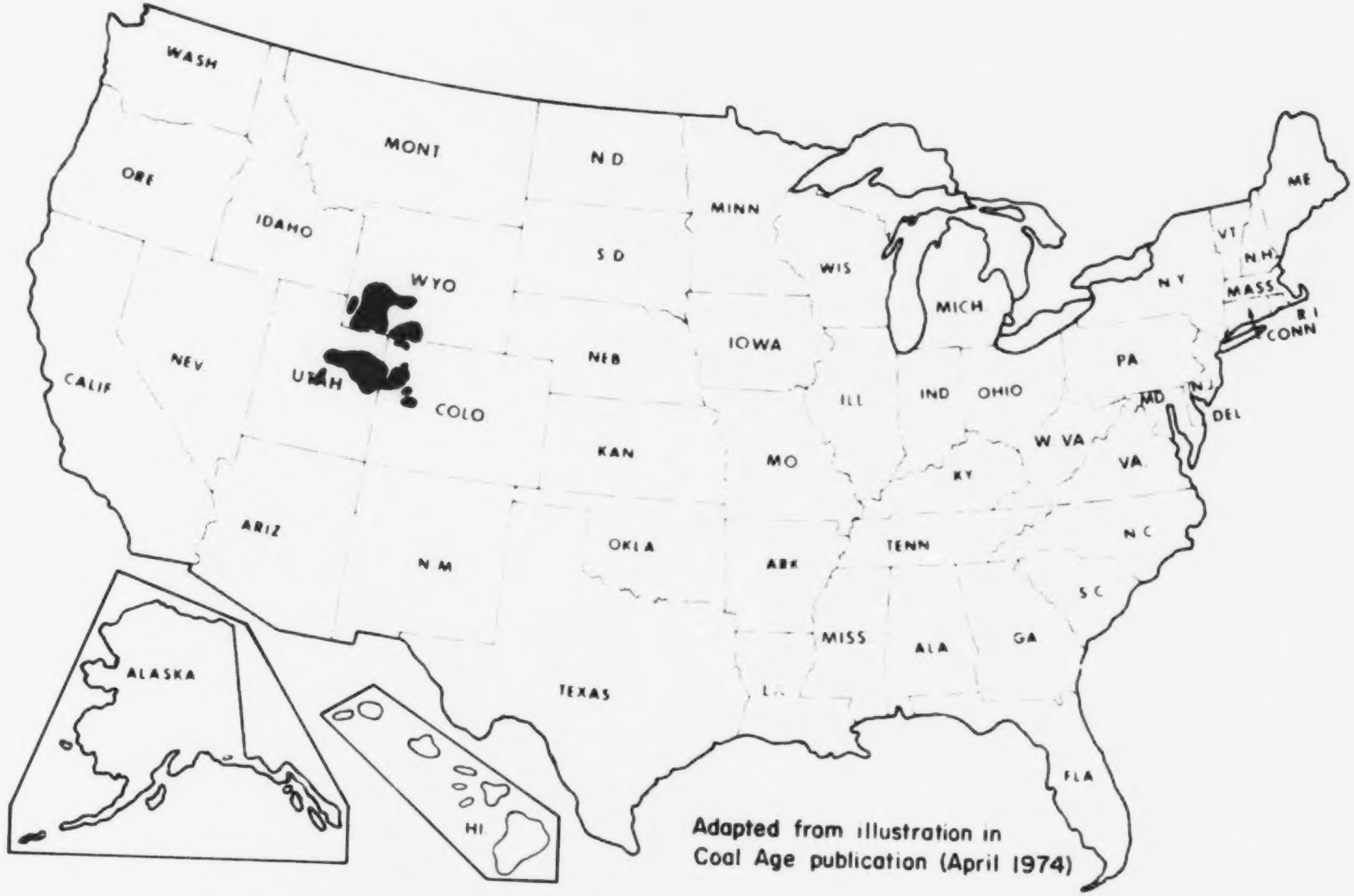
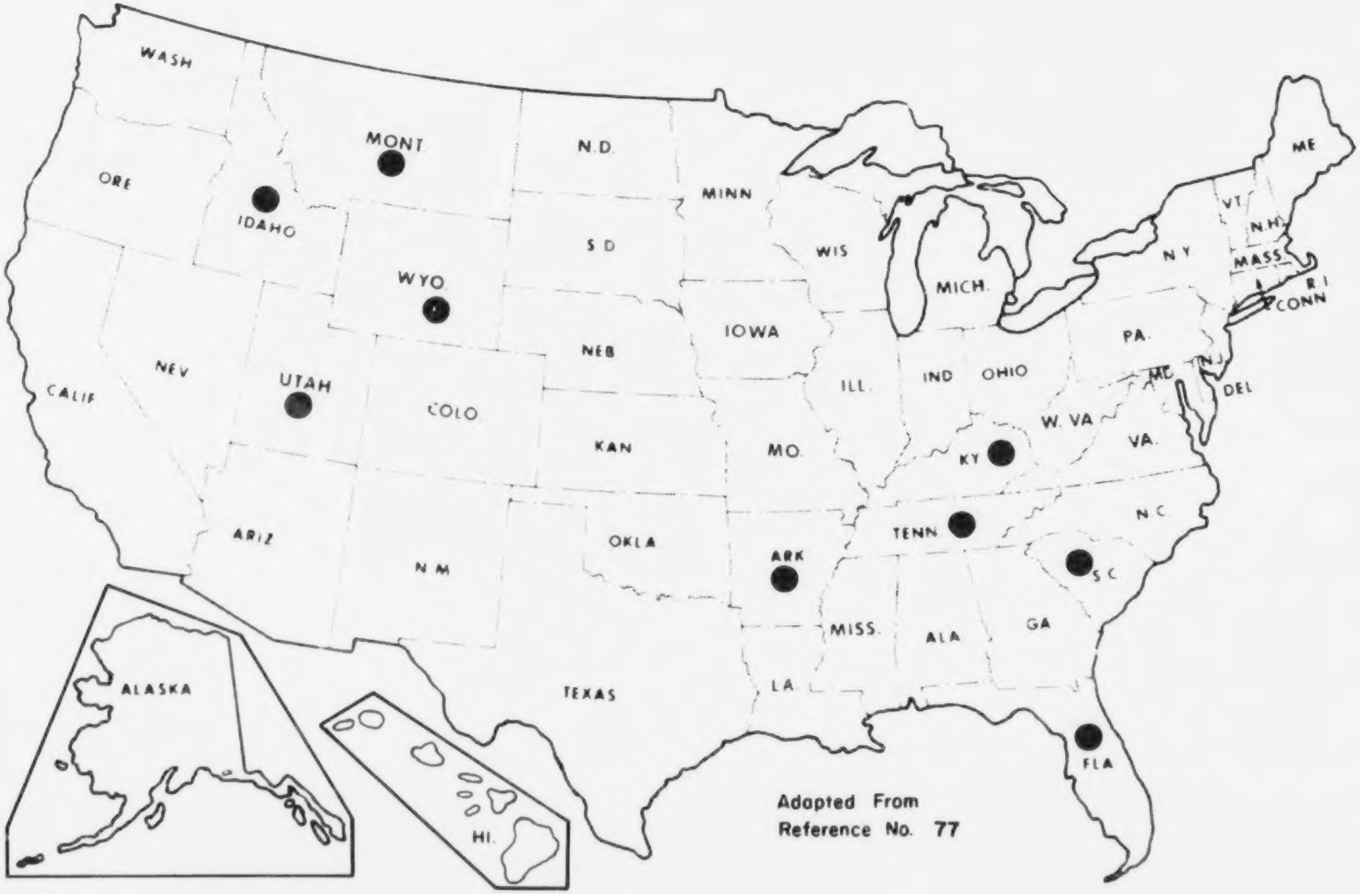
Figure A-II. Sources of molybdenum reserves.



Adapted from illustration in
Coal Age publication (April 1974)

Figure A-12. Sources of oil shale reserves.



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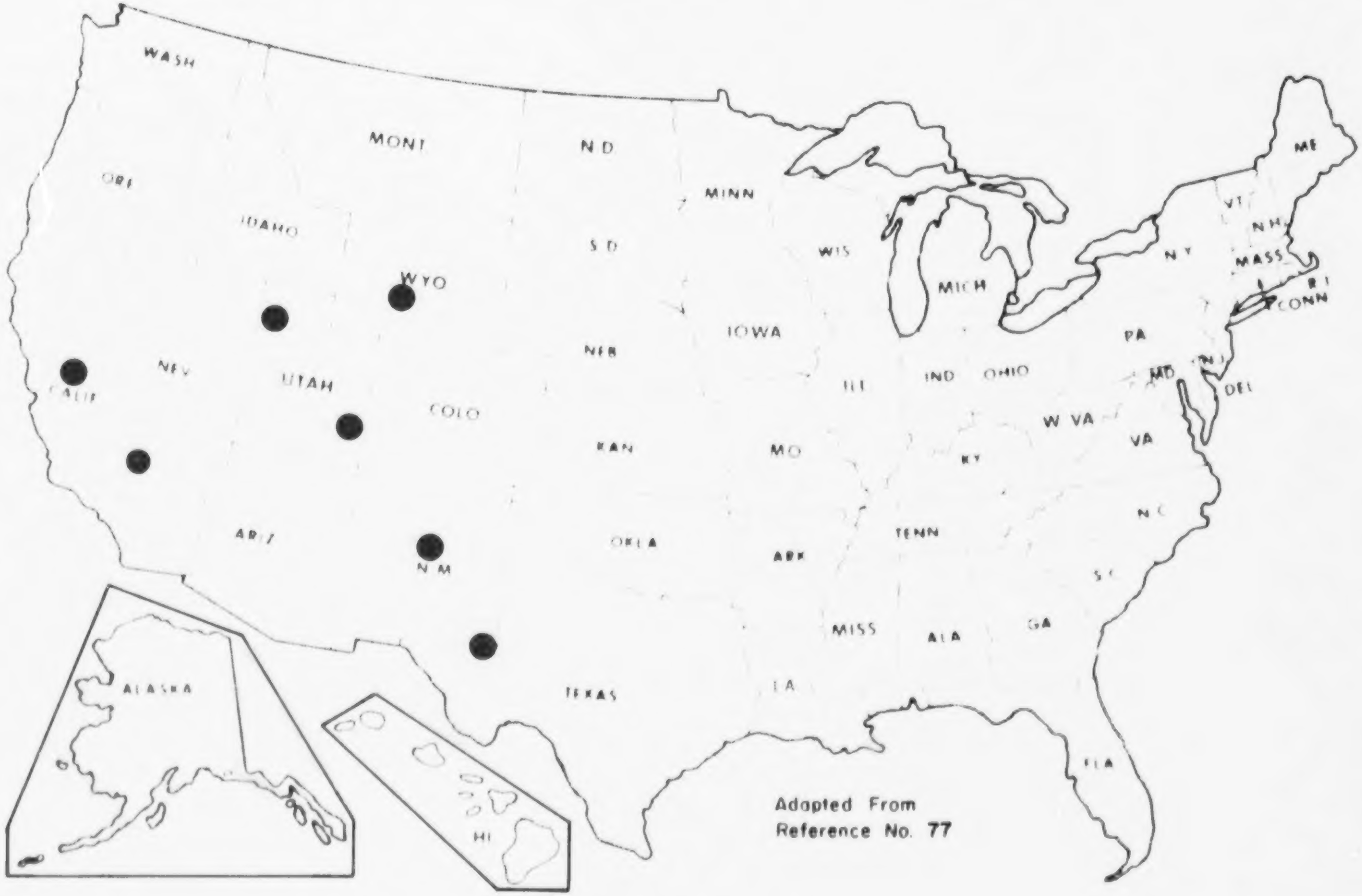
Reference No. 77

Figure A-13. Sources of phosphate rock reserves.



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Reference No. 77

Figure A-14. Sources of potash reserves.

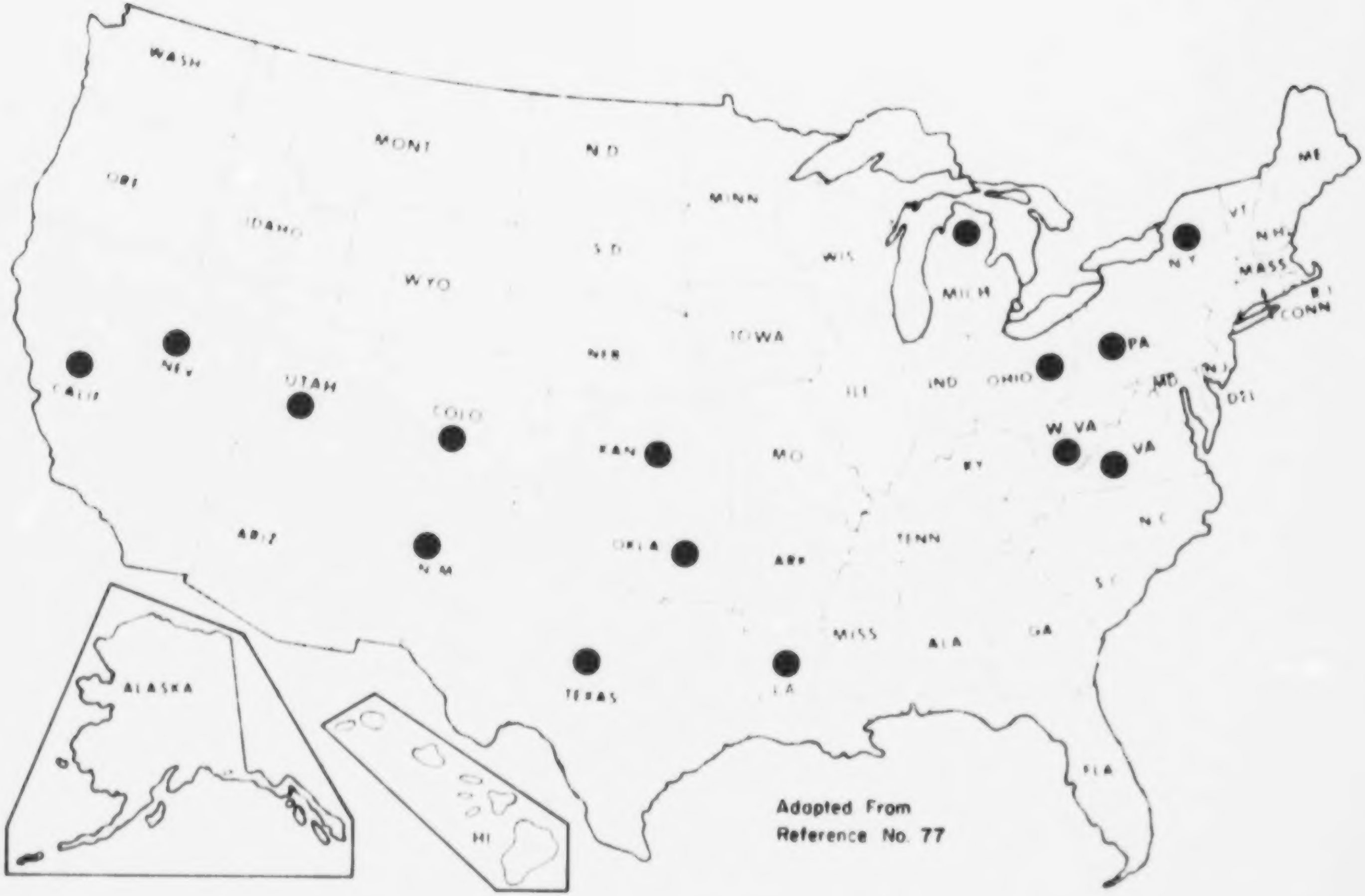

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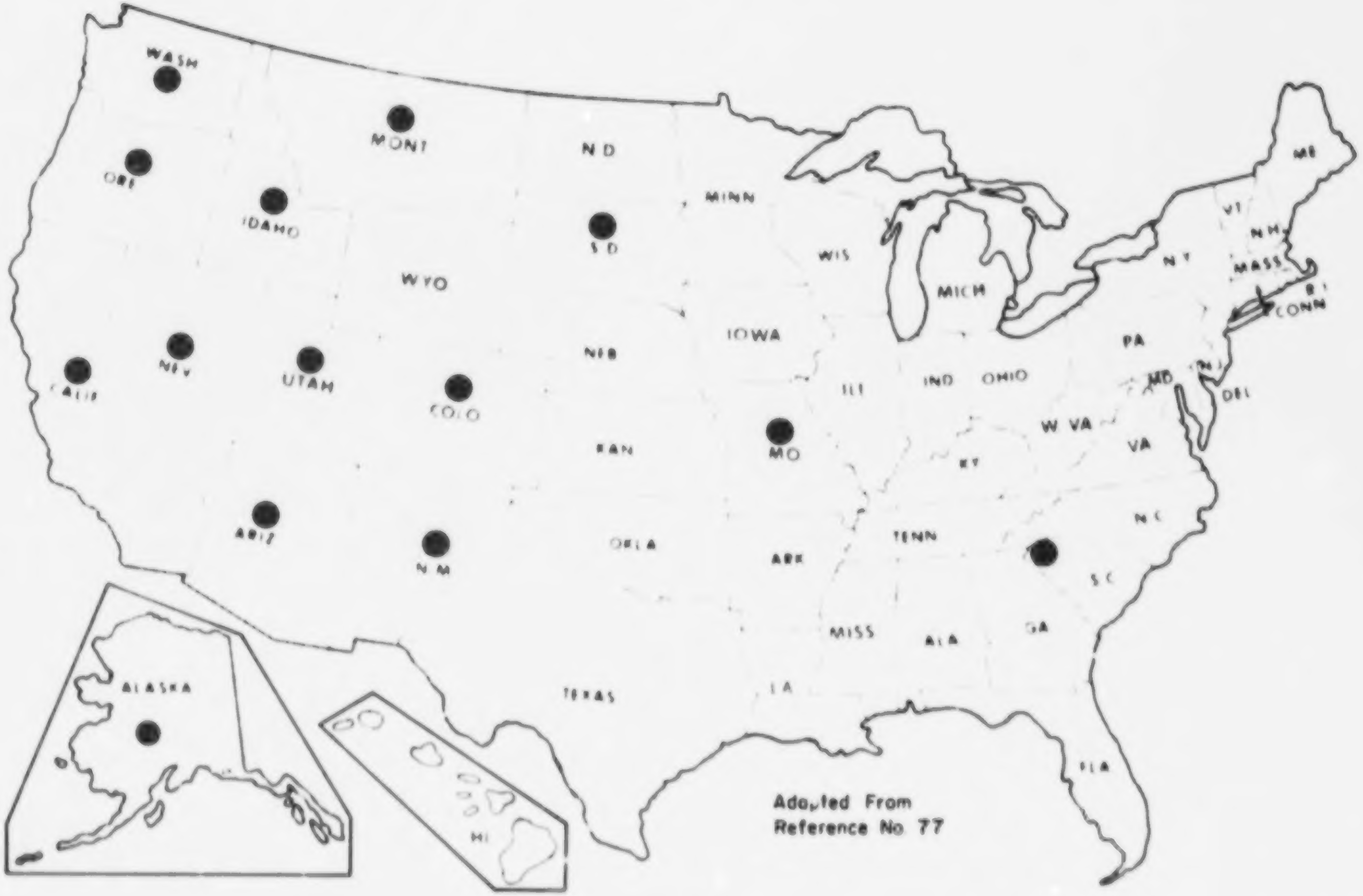
Figure A-15. Sources of salt reserves.



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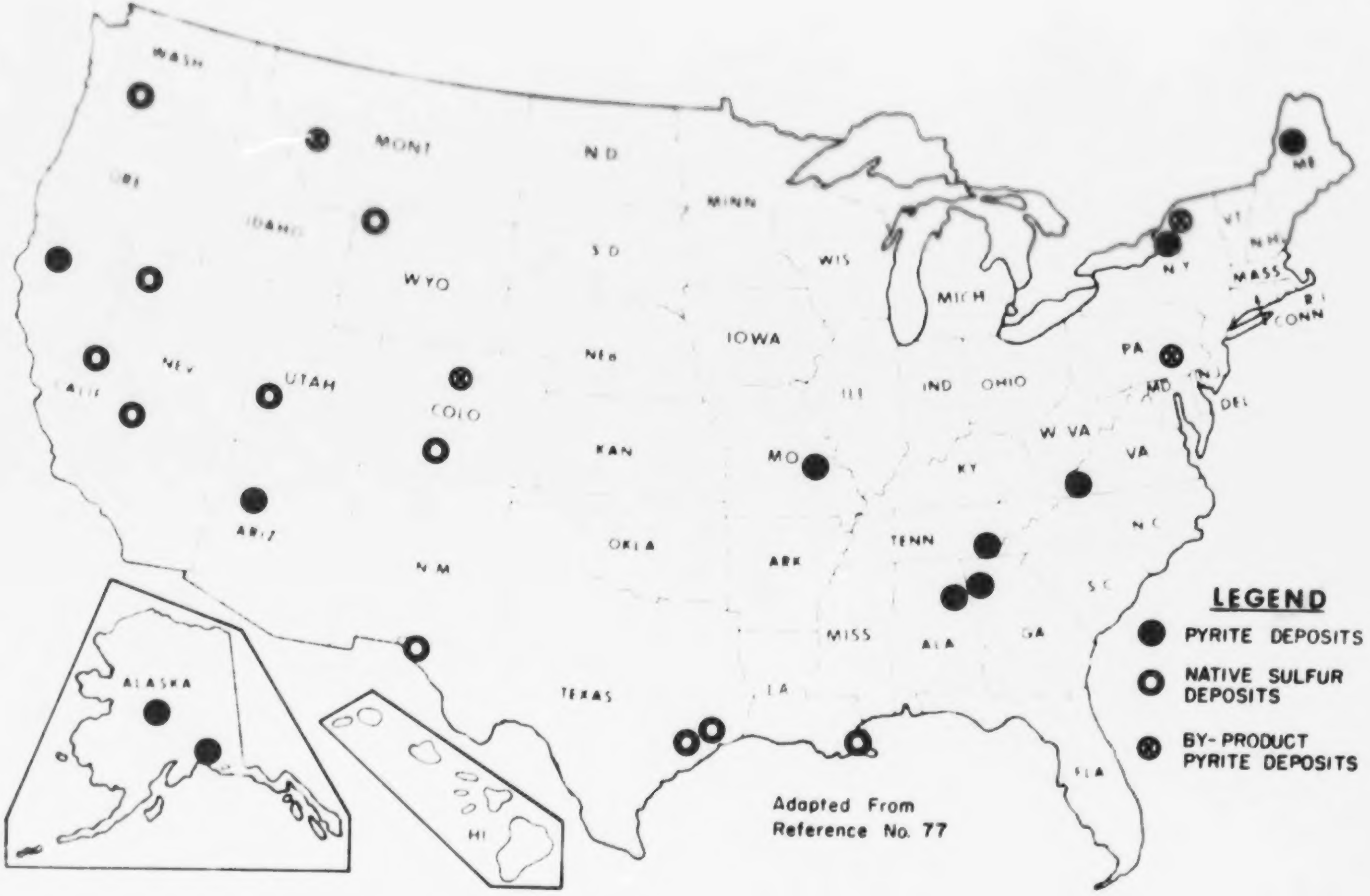
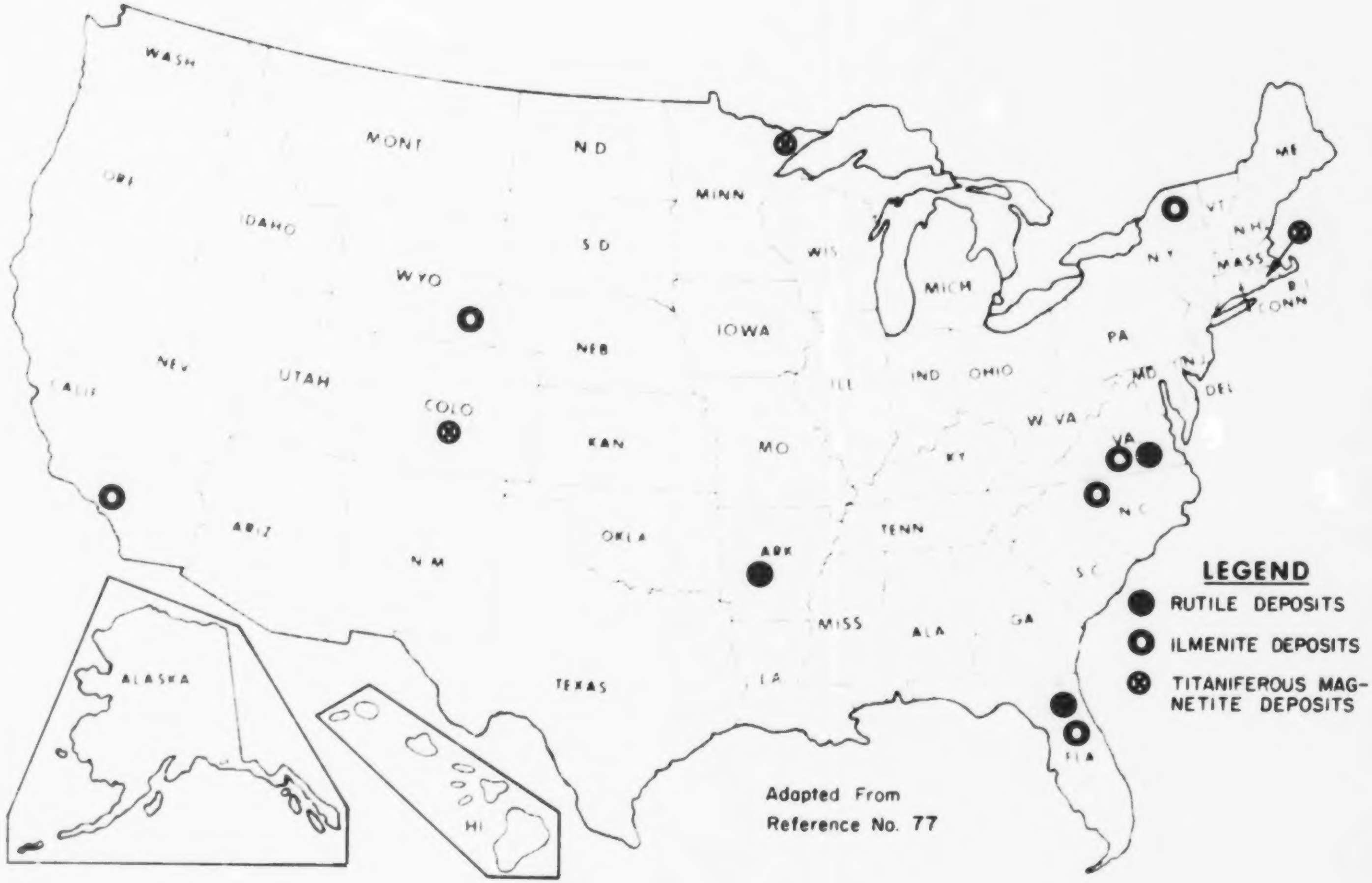
Reference No. 77

Figure A-16 Sources of silver reserves



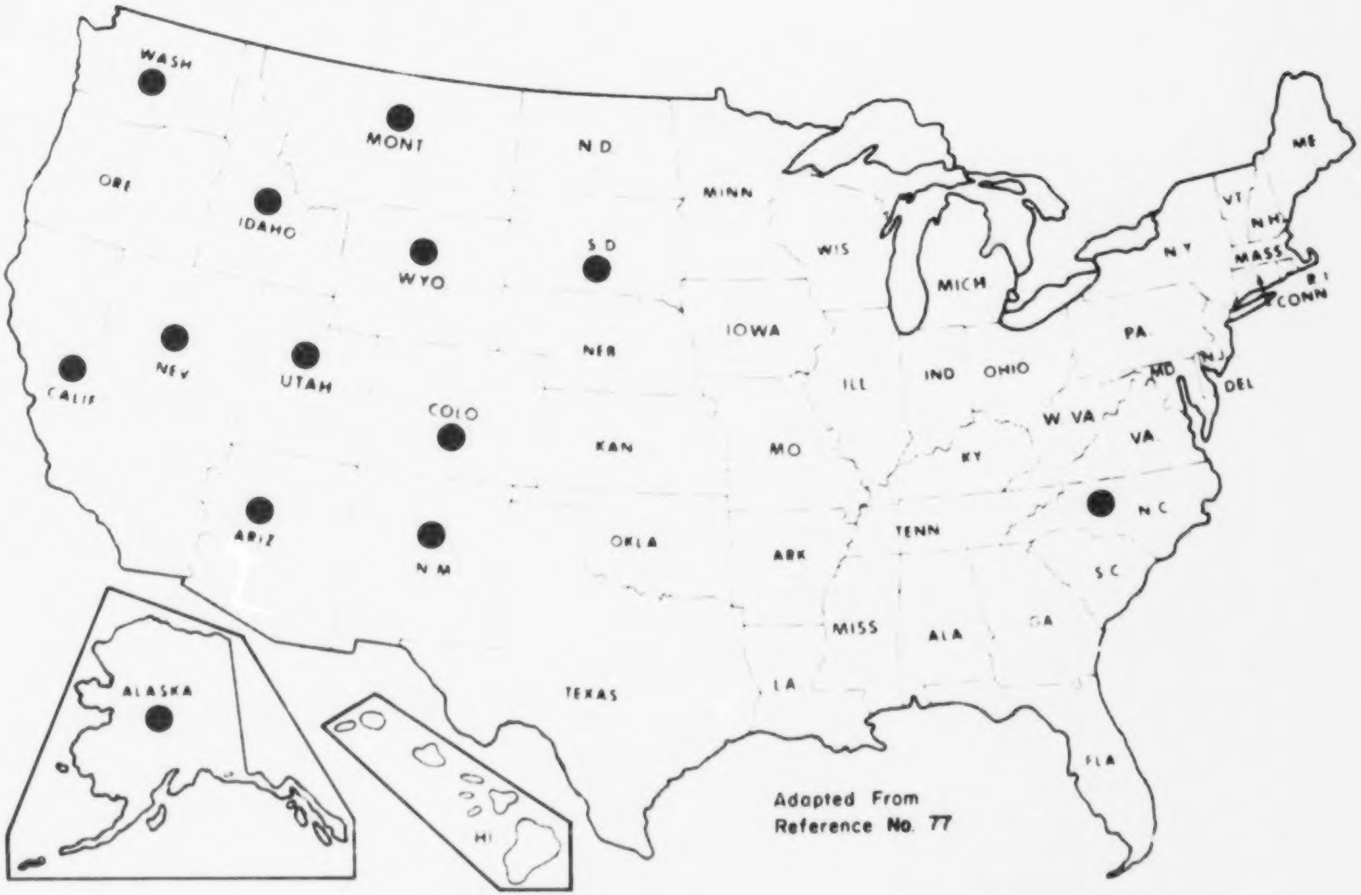
Adapted From Reference No. 77

Figure A-17. Sources of sulfur and pyrite reserves



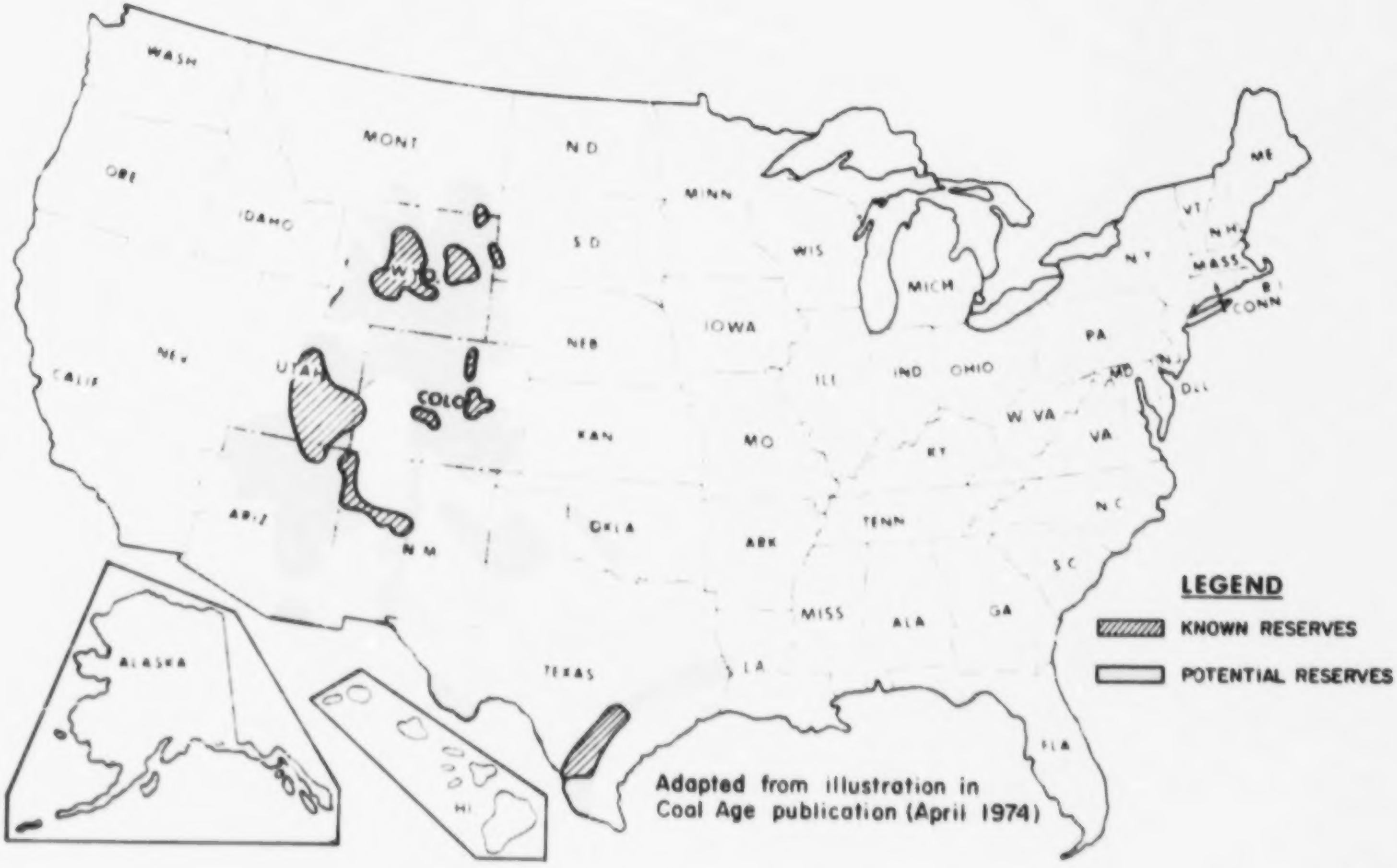
Adapted From Reference No. 77

Figure A-18. Sources of titanium reserves.



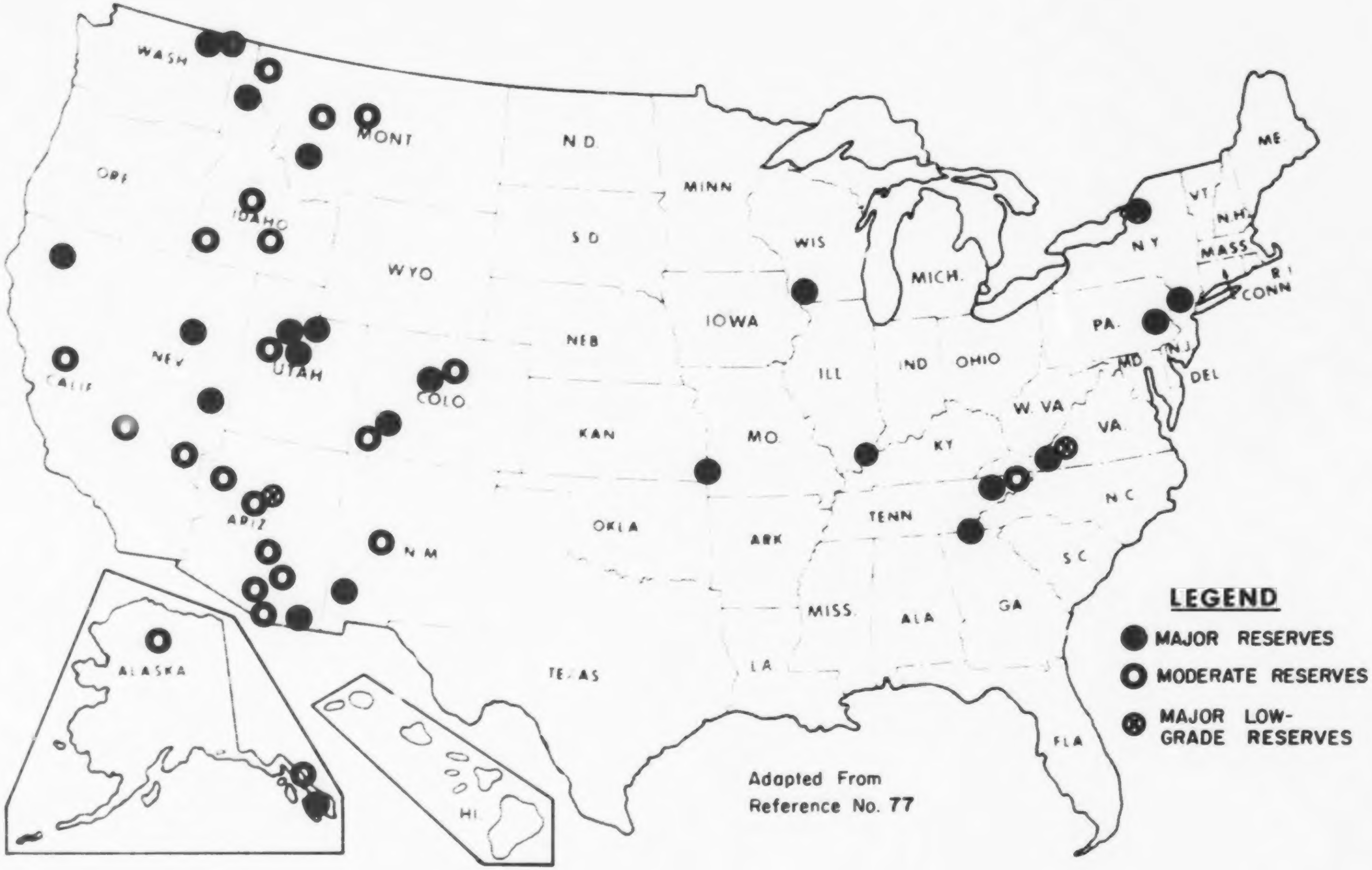
Adapted From
Reference No. 77

Figure A-19. Sources of tungsten reserves.



Adapted from illustration in
Coal Age publication (April 1974)

Figure A-20. Sources of uranium reserves.



Adapted From
Reference No. 77

Figure A-21. Sources of zinc reserves

APPENDIX B

SYNOPSIS OF SELECTED STATE ABANDONED MINED LANDS PROGRAMS

ILLINOIS ABANDONED MINED LAND RECLAMATION PROGRAM

Illinois coal fields have been extensively inventoried through the joint efforts of the Department of Mines and Minerals, Institute for Environmental Quality and the Cooperative Wildlife Research Laboratory - Southern Illinois University at Carbondale. Using expert state and university personnel and consultants, the inventory began in 1970 and concluded in 1973. Objectives of the study included: determination of acreage, ownership, condition and utilization of lands affected by surface mining: development of cost-effective alternative reclamation plans; design and development of demonstration projects that would establish and verify reclamation costs and technological feasibility of alternative reclamation methods; and to develop and apply data collection and management systems.

Aerial photographs and various mine, plot, and highway maps were used to locate surface mined areas. Extensive field investigations were conducted by ground crews to gather detailed water and terrestrial quality data. Results of study defined some 42,000 hectares (103,000 acres) of land as having been mined prior to 1962 (when the first surface mining statute was enacted). Of this total, approximately 7200 hectares (17,800 acres) were identified as problem areas.

Early in 1975, the Illinois General Assembly passed the Abandoned Mined Lands Reclamation Act. The Act provides for restoration of lands affected by surface or underground mining prior to January 1, 1962.

An Abandoned Mined Lands Reclamation Council was also created by the Act. Council memberships consist of directors of the Departments of Mines and Minerals, Conservation, Agriculture, Business and Economic Development, Local Government Affairs, Environmental Protection, and Illinois Institute for Environmental Quality. The Lieutenant Governor serves as chairman of the Council.

The Council is responsible for designating the abandoned lands to be acquired and reclaimed by the Department of Mines and Minerals as well as establishing priority areas for acquisition.

MARYLAND ABANDONED MINE DRAINAGE CONTROL PROGRAM

In 1970 the Maryland General Assembly passed the Abandoned Mine Drainage Control Act which authorized the Secretary of Natural Resources to:

a. "acquire and rehabilitate land occupied or degraded by any abandoned deep or strip mine to prevent the land from contributing to water pollution and take whatever other measures are necessary to prevent, control, and abate water pollution from any abandoned mining areas."

b. "implement the provisions of the act by methods including, but not limited to, backfilling, grading, revegetating abandoned strip mines, sealing abandoned deep mines, and controlling erosion and water drainage."

The Secretary of Natural Resources subsequently assigned the operational aspects of the program to the Water Resources Administration. The act also designated the Department of General Services to supervise matters of land acquisition, construction to be performed, engineering plans and specifications, listing of contracts and payment relating thereto.

The Abandoned Mine Drainage Control Act authorized a State loan of five million dollars ($5,000,000) known as the Mine Reclamation and Water Quality Restoration Loan of 1970. The Board of Public Works administers loan expenditures which are specifically designated for contractual services, land acquisition, construction and related expenses.

Initial planning and watershed priority establishment was conducted by Water Resources staff. Consultants were then retained to conduct abandoned mine drainage control feasibility surveys in the top five priority watersheds designated by Water Resources.

To date, approximately $800,000 has been expended to accomplish comprehensive inventories and analyses of drainage sources in five watersheds. Federal assistance totaling $122,500 has been utilized for watershed studies and an additional $2,429,000 of federal grants will supplement state funds for engineering plans and construction in the top five priority watershed areas.

PENNSYLVANIA OPERATION SCARLIFT

On January 19, 1968 the Pennsylvania Legislature approved the Land and Water Conservation and Reclamation Act. Section 16 of this Act provided for the expenditure of $200 million over a ten year period for mine area restoration. Of this total, $150 million was designated for prevention, control and elimination of stream pollution from mine drainage, $20 million for prevention, control and elimination of air pollution from abandoned burning coal refuse banks provided such land and bank material is publicly owned, and $30 million for the prevention of surface subsidence above abandoned mine operations, for the control and extinguishment of surface and underground fires from abandoned mines.

Although the Act requires public ownership only in the case of burning refuse banks and the land on which they are situated, there are provisions also for filing liens on private property on which any work is accomplished under this Act.

Funds under this Act are used directly by the Department of Environmental Resources for studies, planning, design, construction, and administration of the specified reclamation items--grants on loans are not authorized. Expenditures and/or commitments to date are:

	Millions
Stream Pollution Abatement	$82.0
Air Pollution Control (Refuse Bank Fire)	19.5
Underground Fires and Subsidence Control	29.5
	$131.0

The acid mine drainage program is implemented in four basic steps. First, a watershed study is conducted on those watersheds where past mining has resulted in polluted streams from mine drainage. After careful analysis of the study, those recommended projects that are deemed to make significant contributions to the abatement of mine drainage within a reasonable cost are further defined. Scopes of work for these selected projects are then sent for detailed design.

During the design period, action is taken to obtain necessary real estate easements and releases. This has proved to be a major restraint in the program because of the unwillingness of some landowners to permit reclamation projects on their lands.

Once design and real estate actions are completed, the projects are then publicly advertised for construction bids. Upon completion of construction, a post-construction monitoring program is initiated. This program seeks to evaluate the success of the project.

VIRGINIA ORPHANED LAND RECLAMATION PROGRAM

The Virginia Orphaned Land Reclamation Program began July 11, 1972, and is administered by the Department of Conservation and Economic Development, Division of Mined Land Reclamation. An Orphaned Land Advisory Committee was also created to advise the Division of Reclamation on reclaiming orphaned lands and establishing reclamation priorities. Committee membership is composed of private citizens from the coal fields.

The Program is funded by coal surface mining permit fees and renewal fees. These fees are $30 per hectare ($12 per acre) for each permitted and $15 per hectare ($6 per acre) renewal fee for each undisturbed acre. As funds are accumulated, areas of high priority are presented to the Orphaned Land Advisory Committee for their approval.

Since enactment of the Program, the Division of Reclamation has located and plotted on USGS topographic maps the location of orphaned mined sites in Virginia's coal fields. Reclamation has been completed on approximately 85 hectares (210 acres). Some 7300 hectares (18,000 acres) have been identified as needing reclamation.

KENTUCKY ORPHAN LAND RECLAMATION PROGRAM

In 1972 the Kentucky General Assembly established a revolving fund to reclaim orphaned strip mine land. The Legislature provided $500,000 to implement the program and added $1 million in 1974. The goal of the Orphaned Lands Program is to restore the land to productive use for recreation, conservation, industrial, residential and agricultural purposes. The land is to be purchased, reclaimed and then resold for private use and the money returned to the revolving fund for purchase of more land.

To date, approximately 270 hectares (670 acres) have been purchased from coal companies -- 105 hectares (260 acres) in Muhlenberg County near Greenville and 166 hectares (410 acres) in Hopkins County near Earlington. The two sites are being reclaimed in a pilot project sponsored by the U. S. Department of Labor, its Job Corps Training Program, and the Kentucky Department for Natural Resources and Environmental Protection. Some 44,500 hectares (110,000 acres) of abandoned strip mine land will be encompassed in the total program.

Contact Person:

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Frankfort, Kentucky 40601

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OHIO LAND REBORN

At the time of enactment of Ohio's 1972 Strip Mine Law, the Ohio General Assembly also created a Board on Unreclaimed Strip Mined Lands. As a part of that law, the Board was established to guide restoration of lands and waters affected by coal mining prior to 1972. More specifically the Board was charged with responsibility of "gathering information, studying and making recommendations concerning the number of acres, location, ownership, condition, environmental damage resulting from the condition, cost of acquiring and reclaiming to the standards in the 1972 Ohio Strip Mine Law, and possible future uses and value of eroded lands within the State, including land affected by strip mining for which no cash is held in the Strip Mining Reclamation Fund (fortified performance bonds)."

The objectives established for the study included basic data development (physical and biological, land use, and socio-economic characteristics), determination of potential land uses, estimation of land values, development of reclamation costs, determination of legal tools available to the State and private interests in reclaiming land, and development of public grant/private financing opportunities.

Acting through the Department of Natural Resources, the Board assembled a team of professionals in the needed project disciplines, and began work on the different project tasks so that results of the study (named Land Reborn) could be submitted to Ohio General Assembly for their approval on January 1, 1974. The multidisciplined team of consultant firms and State experts proceeded with a number of tasks. High level aerial photography was made to identify the mined lands. More than 8,000 aerial photographs were taken to produce 250 photomaps outlining the mined lands. Field crews collected ground data and gathered water samples. The entire 28,500 square kilometer (11,000 square mile) area of the coal field was divided into 79 watersheds for ease of handling the amount of data being accumulated and to provide sensible working units within this large total area.

Appraisers gathered information on current land values before and after reclamation. Public land ownership was defined. Factors such as development demand, economic need, visual quality, and public visibility were incorporated. Cost estimates were made for all of the required reclamation work.

Potential sources of funding were explored, implementation procedures developed. and a series of reclamation priorities were defined. Funds for the study were appropriated out of monies in the state treasury for the sum of $250,000. Additional revenues for abatement and reclamation projects are to be secured from a severance tax on natural resources.

Feasibility studies for high priority watersheds are anticipated to begin within the next year.

APPENDIX C

GLOSSARY

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GLOSSARY

Abatement - Elimination of pollutional effects upon the aquatic environment caused by mine drainage.

Alkaline - Having the qualities of a base; i.e., a pH above 7.0.

Alluvial - Describes earth materials that have recently (geologic time scale) been deposited by moving water.

Aquatic - Of or relating to water.

Aquifer - A water-bearing stratum of permeable rock, sand, or gravel.

Apex - The top of terminal edge of a mineral vein on the surface or its nearest point to the surface.

Auger - Any drilling device in which the cuttings are mechanically and continuously removed from a borehole without the use of fluids.

Backfilling - The transfer of previously moved material back into an excavation such as mine, ditch, or against a constructed object.

Bench - A level layer of earth or rock adjacent to a surface mine site.

Bucket Wheel Excavator - A continuous digging machine originally designed and used in large-scale stripping and mining of East German brown coal deposits. Its digging mechanism is essentially a boom on which is mounted a rotating vertical wheel having buckets on its periphery. As the rotating wheel is pressed into the material to be dug, the buckets cut, gather, and discharge the material onto a conveyor belt where it is moved to the mined-materials transport system.

Bulldozer; dozer - A tractor on the front end of which is mounted a vertically curved steel blade held at a fixed distance by arms secured on a pivot or shaft near the horizontal center of the tractor. The blade can be lowered or tilted vertically by cables or hydraulic rams. It is a highly versatile piece of earth excavating and moving equipment especially useful in land clearing and leveling work, in stripping topsoil, in road and ramp building and in floor or bench cleanup and gathering operations.

Condemnation - The act of judicially declaring land convertible to public use under the right of eminent domain.

Contour Regrading - A technique which involves regrading a mine to a shape that closely resembles original land contour.

Deep Mine - An underground mine.

Dip - The angle at which a plane (usually a rock bedding plane) is inclined from the horizontal.

Dragline - A type of excavating equipment which casts a rope-hung bucket a considerable distance, collects the dug material by pulling the bucket toward itself on the ground with a second rope, elevates the bucket, and dumps the material on a spoil bank, in a hopper, or on a pile.

Dredge - Any apparatus used for excavating under water. Usually a large raft, barge, or boat on which is mounted a chain of buckets, suction pumps, or other devices to dig and elevate the materials from a subaqueous deposit.

Drift - A deep mine entry driven directly into a horizontal or near horizontal mineral seam or vein when it outcrops or is exposed at the ground surface.

Effluent - Any water flowing out of the ground or from an enclosure to the surface flow network.

Eminent Domain - A right of government to take private property for public use through its sovereign power over all lands within its jurisdiction.

EPA - Abbreviation for Environmental Protection Agency.

Erosion - Process whereby solids are removed from their original location on the land surface by hydraulic or wind action.

Exploration - The work involved in gaining a knowledge of the size, shape, position, and value of an ore body.

Front End Loader - A tractor loader with a digging bucket mounted and operated at the front end of the tractor.

Gob - Rock that has a high carbon content - usually referring to dark colored mining waste material.

Haul Road - A road built to carry heavily loaded trucks. The grade is limited on this type of road and usually kept to less than 17 percent of climb in direction of load movement.

Head (of water) - Water pressure expressed as the feet of elevation difference between the top of the water and the point at which the pressure is exerted.

Highwall - The exposed vertical or near vertical wall associated with strip or area surface mines.

Hydraulic Giant - A device for directing a high-pressure jet of water in hydraulic mining. It is essentially a swivel-mounted, counter-weighted nozzle attached to a tripod or other type of stand and so designed that one man can easily control and direct the vertical and lateral movements of the nozzle.

Hydrology - The science that relates to the water systems of the earth.

Impoundment - A body of water formed by collecting and confining water, as in a reservoir.

Infiltration - Water entering the ground water system through the land surface.

Inundate - To cover with or submerge in water.

Leaching - Extraction of a mineral from an ore by selectively dissolving it in a suitable solvent.

Lien - A charge upon real or personal property for the satisfaction of some debt or duty ordinarily having arisen from an operation of law.

Litigation - A legal contest conducted through judicial processes.

Mining - The process of obtaining useful minerals from the earth's crust which includes both underground excavations and surface workings.

Mulching - The addition of materials (usually organic) to the land surface to curtail erosion or retain soil moisture.

Neutralization - The process of adding an acid or alkaline material to waste water to adjust its pH to a neutral position.

Ore - A mineral deposit that can be recovered at a profit under the existing economic conditions.

Outcrop - The surface exposure of bedrock or strata.

Outslope - The face of a strip mine bench or spoil pile opposite the highwall.

Overburden - The nonsalable rock material that overlies a mineable mineral.

Parameter - Any of a set of physical properties whose values determine the characteristics or behavior of something.

pH - The negative logarithm to the base ten of the hydrogen ion activity. pH_7 is considered neutral. Above 7 is basic - below 7 is acidic.

Photogrammetrics - The process of creating topographical mapping from stereo aerial photographs.

Placer Deposit - Unconsolidated deposits of detrital material containing valuable mineral.

Pollution - Environmental degradation from man's activities.

Pyrites - Any of various metallic-looking sulfides of which Ferrous Sulfide (pyrite) is the most common.

Radioactive - Of, caused by, or exhibiting the property possessed by some elements (uranium) of spontaneously emitting alpha, beta or gamma rays by the disintegration of the nuclear of atoms.

Raise - A vertical or inclined opening driven upward from a level to connect with the level above, or to explore the ground for a limited distance above one level.

Reclamation - The procedures by which a disturbed area can be reworked to make it productive, useful, non-polluting or aesthetically pleasing. Reclamation does not necessarily imply return of the land to its original physical state or condition.

Refuse - Rock that has a high carbon content - usually refers to the dark colored mining waste extracted from underground mines.

Rehabilitation - A process whereby the land will be returned to a form and productivity in conformity with a prior land use plan including a stable ecological state that does not contribute substantially to environmental deterioration and is consistent with surrounding aesthetic values.

Reserve - That portion of the actual identified resources material which can be economically and legally extracted at the time of determination.

Resource - Material known to exist in the earth's crust or judged by geologic inference and extrapolation as likely to exist.

Restoration - Return of a disturbed area to its former configuration or physical state to increase usefulness, productivity and aesthetic quality while reducing pollution.

Riprap - Rough stone of various sizes placed compactly or irregularly to prevent erosion.

Runoff - That part of precipitation that flows over the land surface from the area upon which it falls.

Scarification - Decreasing the smoothness of the land surface.

Scraper - A self-loading carrier device with a scraperlike, retractable bottom, sometimes self-propelled and used especially for excavating and hauling unconsolidated or crushed rock and earthy materials.

Sediment - Solid material settled from suspension in a liquid medium.

Settling Pond - A holding or retention pond which provides sufficient residence time to allow the precipitation of suspended solids.

Shovel - Any bucket-equipped machine used for digging and loading earthy or fragmented rock materials.

Silt (Sediment) - Solid material settled from suspension of a liquid medium.

Slope Stability - The resistance of any inclined surface, as the wall of an open pit or cut, to failure by sliding or collapsing.

Slugging - The sudden increase in concentration of stream pollutants, such as silt, acid, iron, or sulfate, resulting from heavy rainfall rapidly washing the leached pollutants from the land surface and underground mines.

Sluicing - A separation of minerals in a flowing stream of water.

Spiral System - In open-pit mining, a haul road arranged spirally along the perimeter walls of the pit so that gradient of road is more or less uniform from bottom to the top of the pit.

Spoil Material - The waste material removed from the strip cut that is not considered a useful product.

Spoil Pile - The area where mine waste or spoil materials are disposed or piled.

Stope - An excavation from which ore has been extracted. The term stoping is commonly applied to the extraction of ore, but does not include the ore removed in sinking shafts and in driving levels, drifts and other development openings.

Strike - The horizontal course or bearing of an inclined bed, stratum, or vein; the direction of a horizontal line in the plane of an inclined bed, stratum, or vein.

Strip Mine - A surface mine where the overburden is removed to expose the mineable material.

Stripping - The removal of earth or non-ore rock material as required to gain access to the ore or mineral materials wanted; the process of removing overburden or waste material in a surface mining operation.

Stripping Ratio - The unit amount of spoil or waste that must be removed to gain access to a similar unit amount of ore or mineral material.

Subsidence - The surface depression over an underground mine that has been created by subsurface caving.

Surface Mine - A mine facility that is generally conducted from the land surface. It does not have a mineral roof.

Tailings - Mineral refuse from a milling operation usually deposited from a water medium.

Terrace Regrading - Reclamation technique whereby the highwall is reduced and a terrace is formed.

Terrestrial - Of or relating to land.

Topography - The configuration of a surface including its relief and the position of its natural and man-made features.

Underdrain - A pervious backfilled trench containing a pipe or stone for the purpose of intercepting ground water or seepage.

USGS - Abbreviation for United States Geological Survey.

Vein - A mineralized zone having a more or less regular development in length, width, and depth to give it a tabular form and commonly inclined at a considerable angle to the horizontal.

Watershed - Surface region or area contributing to the supply of a stream or lake; drainage area, drainage basin, catchment area.

Yellowboy - The unsightly, orange-red or yellow precipitate of ferric sulfate and hydroxide observed in many streams polluted by mine drainage.

APPENDIX D

REFERENCES

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APPENDIX E

ACKNOWLEDGEMENTS

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